NASA Tech Briefs

Official Publication of
National Aeronautics and
Space Administration
Volume 15 Number 9

Transferring Technology
to Industry and
Government
September 1991

True 3D On Your PC/Workstation

Now, Dr. Saunders Goes To Work Every Day On Venus.

And he's just begun to scratch the surface.

Since August 1990, Steve Saunders and his associates at NASA's Jet Propulsion Laboratory have been analyzing the pictures coming in from the Magellan spacecraft, built by Martin Marietta.

By using a special radar, Magellan can "see" through the clouded atmosphere of Venus. The resulting imagery shows us a world of volcanoes, lava flows and faults geologically similar to Earth. In fact, the volcanic activity on Venus is so well preserved, that it may help us to better understand the process of volcanoes here on our own planet.

Venus may also be a window into our past, when the Earth was very young. It puts us one step closer to understanding how "twin" planets, so similar in size and location, could evolve so differently. What caused the atmosphere of Venus to change into an out-of-control "greenhouse effect?" What does it mean to our own future here on Earth?

Steve Saunders and the people at JPL are working hard to bring Venus down to Earth. At Martin Marietta, we're proud that we can help them along the way.

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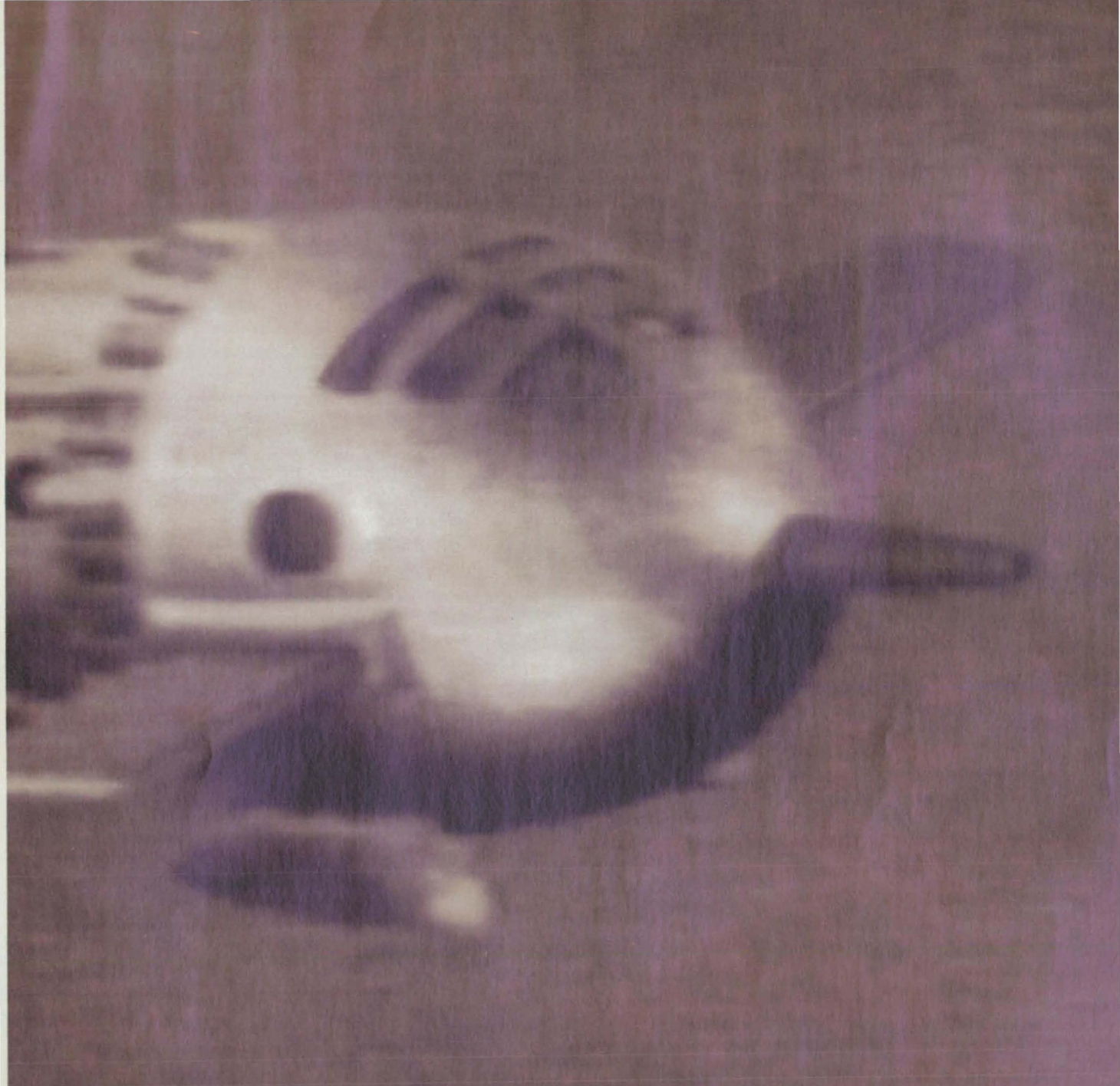

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NASA Tech Briefs

Transferring Technology to Industry and Government

September 1991
Volume 15 Number 9

BPA ABP

Illustration courtesy Ames Research Center

A new telescoping boom for helicopters promises to make rescue operations at sea easier and safer. See page 130.

SPECIAL FEATURES

TECHNICAL SECTION

DEPARTMENTS

On The Cover: Molecules spin in midair and CAD models leap off the screen with a novel stereoscopic viewing system that brings true 3D depth to computer graphics. Turn to Mission Accomplished, page 12.
(Photo courtesy StereoGraphics Corp.)

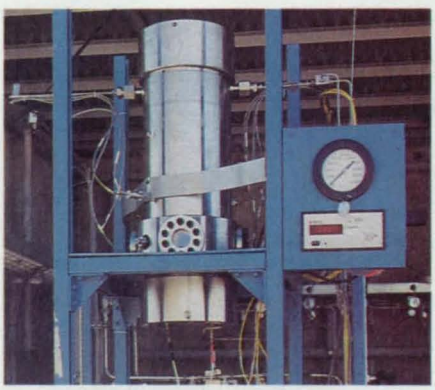

Photo courtesy White Sands Test Facility

NASA has developed a combustion chamber that enables researchers to analyze, in real time, the burning behavior of materials at pressures up to 10,000 psi (page 130).

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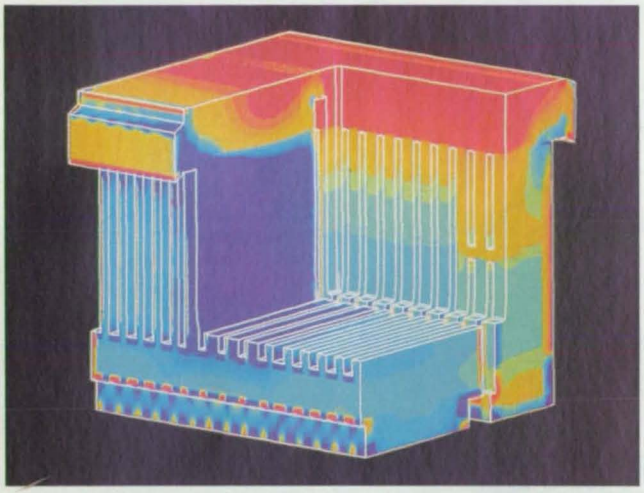

Flow in a computer cabinet: pressure distribution

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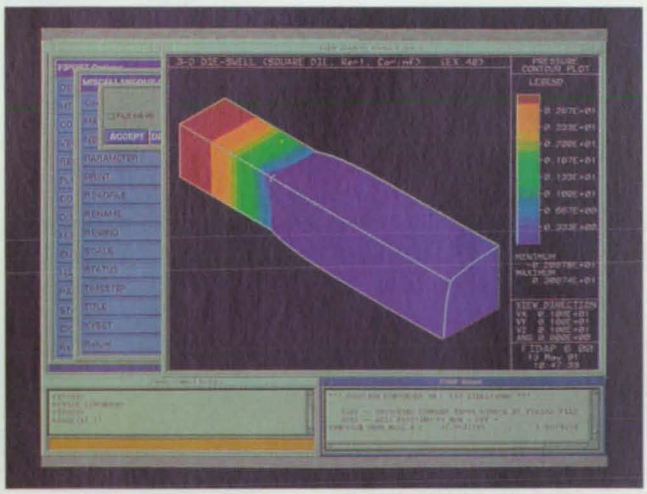

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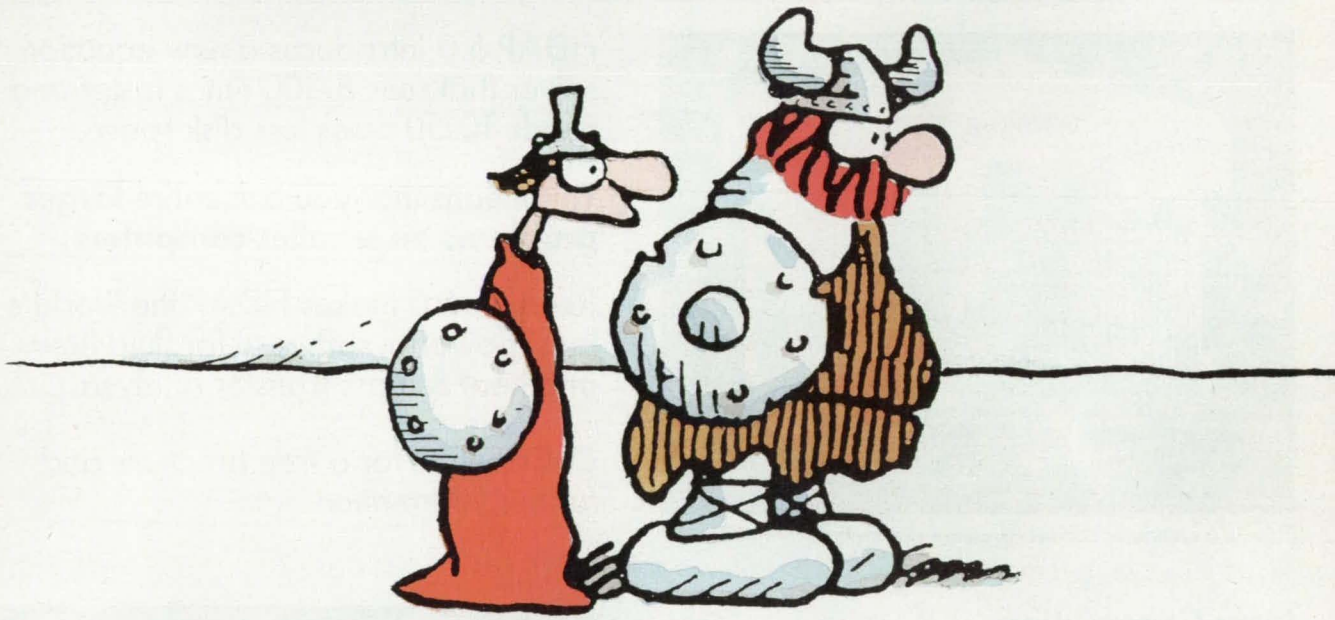
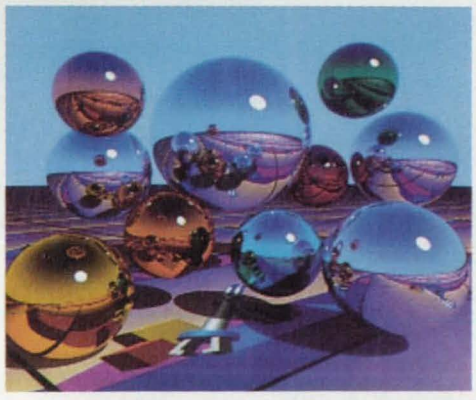
Don't settle for graphics



Read the writing on the wall. You don't want to compromise your image with graphics that don't paint the best picture. With IBM's new line of graphic adapters, you don't have to.

IBM has unveiled new levels of price/performance for fast 2D and 3D solids graphics applications. And the faster you can visualize data, the faster you can get your ideas across. Within the RISC System/6000™ family of POWERstations, you can get graphics performance that will really help you make your mark. For instance, the Gt4x graphics subsystem can draw 800,000 2D and 3D vectors and 80,000 Lighted Gouraud-shaded triangles per second, and gives you up to 16.7 million colors to work with to really showcase projects such as solids designs and scientific visualization.



When you really want to display your vision, there's the POWERgraphics GTO

	Gt3	Gt4	Gt4x	GT0
2D Vectors/Second	650K	650K	800K	990K
3D Vectors/Second	NA	400K	800K	990K
Lighted 3D Gouraud-shaded triangles/Second	NA	20K	80K	120K

that don't do you justice.

subsystem which produces almost a million 3D vectors and 120,000 Gouraud-shaded triangles per second, for fast, realistic shading effects.

And for those who need 2D graphics, for things like electrical design, there's the Gt3 that delivers 650,000 2D vectors per second in up to 256 striking colors. Best of all, GTO, Gt4 and Gt4x clearly lead the way on all APIs including X Windows Systems,™ GL,™ graPHIGS™ and Motif.™

These impressive graphics are all part of the family portrait of RISC System/6000 POWERstations and POWERservers— offering performance ranging from 9 to 25 MFLOPS and from 33 to 72 SPECmarks™ and AIX,® IBM's enhanced version of UNIX.® The brains behind the beauty.

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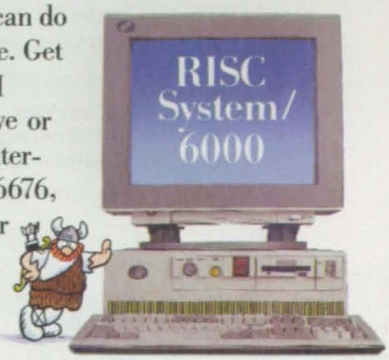

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PC MAGAZINE
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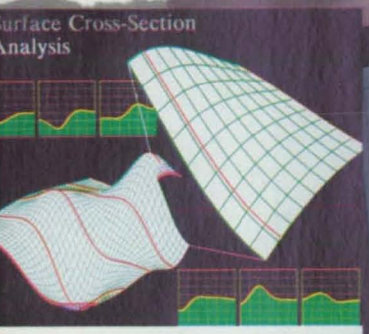

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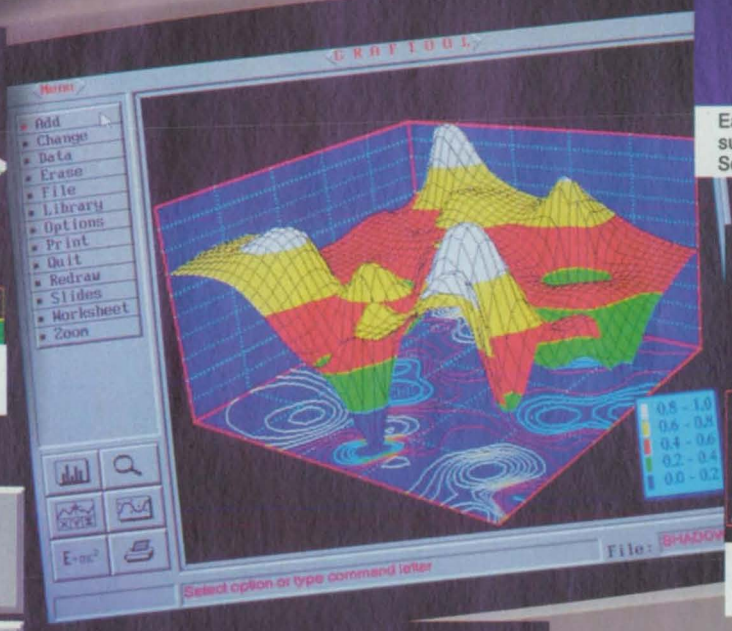

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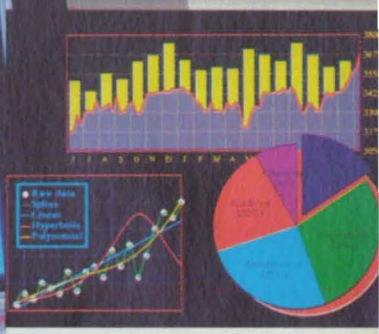

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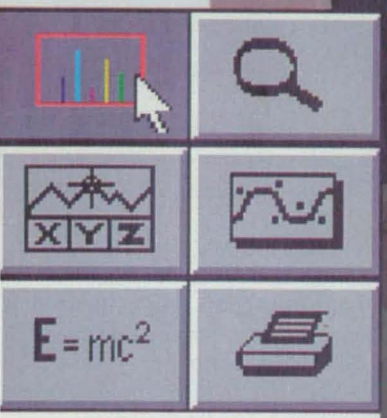

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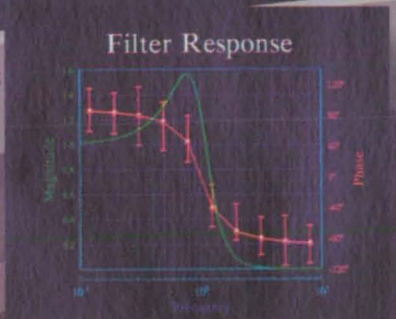
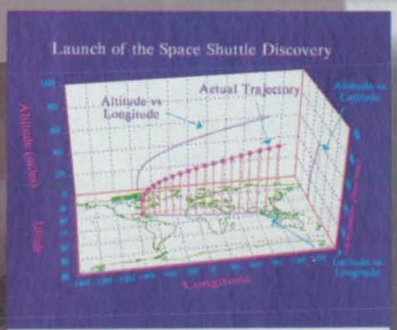


Automate customized graph creation with pre-recorded macro & batch files.



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Mission Accomplished

Stereo 3D adds a new dimension to business presentations.

Through the technology transfer process, many of the systems, methods, and products pioneered by NASA are reapplied in the private sector, obviating duplicate research and making a broad range of new products and services available to the public.

A design engineer dons special glasses and instantly his CAD drawings take on a new dimension, one of vivid depth and definition. Graphic images seem to leap from the computer screen and rotate in midair, allowing the engineer to closely study design details and to detect flaws that might otherwise go unnoticed.

His futuristic design tool is a stereo 3D viewing system called CrystalEyes®, the flagship product of StereoGraphics Corp., San Rafael, CA. The system, which is compatible with any stereo-ready computer or videocassette recorder, consists of wireless, liquid-crystal eyewear and an infrared transmitter. It adds true 3D depth to computer displays by exploiting an effect known as stereopsis, the perception of depth that results when each eye is presented with a slightly different perspective and these two perspectives are fused into a single image by the brain.

Besides engineers, CrystalEyes is used by architects, scientists and executives who need a quick and efficient way to visualize information. It is especially beneficial in molecular modeling and cell biology, which involve viewing of complex, abstract objects. Other applications include such diverse areas as manufacturing, medical imaging, topological mapping, business presentations, and video games.

Here's how the system works: First, stereo images are displayed sequentially on a monitor in alternate frames. The left-hand frame is then channeled to the left eye, and the right-hand frame to the right eye using liquid-crystal lens shutters that turn opaque, transparent, and opaque again in rapid succession. When the left image is displayed for a fraction of a second on the screen, the left lens opens and the right lens closes. When the right image is displayed, the process is reversed. A transmitter connected to the monitor sends a signal to the glasses that synchronizes the shutter and image switching.

The shutter operates at such a high speed—120 frames per second, 60 frames per eye—that the human eye detects no flickering. When closed, the shutter is opaque enough to ensure that the wrong image of a stereo pair doesn't leak through. When open, the shutter is transparent enough to ensure that the image is realistically bright.

A novel stereo video system offers an array of applications in training and simulation. Photos courtesy StereoGraphics Corp.

NASA Provides Testing Ground

StereoGraphics produced the first flickerless viewing product with liquid-crystal lenses in 1985. NASA was one of the initial users of this technology, mainly for flight simulation research, and helped StereoGraphics refine its early prototypes. "NASA's primary asset is its willingness to work with a new technology, try it out, and make suggestions rather than rejecting it out of hand," said David Holbrook, StereoGraphics' vice president of marketing. "By integrating our prototypes into its projects, NASA gave us a means to iron out design problems."

The first-generation displays were "tough to set up and clumsy to operate," recalled Lhary Meyer, a founding partner of the company. The headgear was cumbersome, resembling a welder's helmet, and was tethered to the computer. Adopting changes suggested by Space Agency researchers, Stereo-

Graphics made the eyewear lightweight and wireless, and modified the system so users could view images from virtually any angle. Feedback from NASA laboratories also prompted StereoGraphics to improve the system's portability, said Meyer, and to add the capability for group viewing.

"It's now much easier to forget you have the device on and to believe you're actually in the artificial environment," said Steven Williams, a research engineer at NASA's Langley Center. Langley is employing the stereo display system in a flight simulator that presents pilots with a natural, 3D picture of the world, an "out-the-window" view, with all information in a single format. Tests to date indicate that the depth cues provided by stereoscopic displays enhance the pilots' situational awareness and overall performance.

Scientists at NASA's Ames Research Center use the 3D display technology in computational fluid dynamics (CFD) studies to visualize data sets. According to Eric Hibbard, leader of Ames' Graphics Development Project, stereo display enables interpretation of complex and often massive fluid flow data by revealing spatial relationships and topological structures. "There's no other way to view some of our data," he said. The center has developed software to generate stereo images at a workstation from CFD data, and has also employed the equipment in virtual reality, geology, space science, and seismology research projects.

Walk-Through Simulations

StereoGraphics recently introduced CrystalCAD™, a low-cost system for designing and viewing engineering drawings in 3D. The basic CrystalCAD package includes the CrystalEyes viewing system, software, and CrystalCARD™, a stereo-ready graphics-display controller. CrystalCAD can read in DXF files from AutoCAD and other packages, perform design tasks in stereo 3D, and then export the updated files back to the system that created them. The product can reduce design cycle length and eliminate the need for costly physical prototypes, according to Meyer. Moreover, it enables users to create animated 3D "walk-through" or "fly-through" sequences that render intricate drawings comprehensible even to inexperienced viewers.

The company also offers a turnkey video system for recording and playing back stereo video images. CrystalVIDEO™ includes an RGB 31.5 KHz display, the CrystalEyes viewing system with four pairs of glasses, and dual CCD cameras. Its myriad uses include endoscopic and surgical observations, teleconferencing and training, and remote handling operations in space.

For more information on stereoscopic display technology, contact David Holbrook, StereoGraphics Corp., 2171-H East Francisco Blvd., San Rafael, CA, 94901. ❑

Editor's note: StereoGraphics will demonstrate its 3D viewing systems at Technology 2001, the second national technology transfer conference and exposition, December 3-5 in San Jose, CA.

NASA's input was crucial to the development of new lightweight (85 grams), cordless glasses for stereoscopic viewing.

New Product Ideas

New Product Ideas are just a few of the many innovations described in this issue of *NASA Tech Briefs* and having promising commercial applications. Each is discussed further on the referenced page in the appropriate section in this issue. If you are interested in developing a product from these or other NASA innovations, you can receive further technical information by requesting the TSP referenced at the end of the full-length article or by writing the Technology Utilization Office of the sponsoring NASA center (see page 16). NASA's patent-licensing program to encourage commercial development is described on page 16.

Portable Video/Digital Retinal Funduscope

A lightweight, relatively inexpensive electronic and photographic instrument has been developed for the detection, monitoring, and objective quantification of ocular/systemic disease or physiological alterations of the retina, blood vessels, or other structures in the anterior and posterior chambers of the eye. The instrument can be operated with little training.
(See page 115)

Anthropomorphic Robot Hand and Teaching Glove

A robotic forearm-and-hand assembly manipulates objects by performing wrist and hand motions with nearly human grasping ability and dexterity. Underwater, high-radiation, vacuum, hot, cold, toxic, or otherwise inhospitable environments are potential application sites.
(See page 99)

Ultrasonic Device Monitors Fullness of the Bladder

An ultrasonic device that monitors the fullness of the bladder is self-contained, lightweight, portable, powered by a battery, and tailored for the specific patient through software that can be modified as the patient's behavior changes. The device is intended for use in training people with urinary voiding problems.
(See page 115)

New Polyimide Has Many Uses

A high-performance thermoplastic polyimide is made from 3-4′-oxydianiline and 4,4′-oxydiphthalic anhydride. It has good processing characteristics, low toxicity, and no mutagenicity and can be employed to prepare unfilled moldings, coatings and free films, adhesive tape, adhesively bonded substrates, prepregs, and composites.
(See page 85)

LaRC-RP41:a Tough, High-Performance Composite Matrix

A new polymer exhibits increased toughness and resistance to microcracking. The polymer has potential as a high-temperature matrix resin, adhesive, and molding resin. Applications could include automobiles, electronics, aircraft, and aerospace structures.
(See page 82)

Long-Lived, Replaceable Low-Pressure Seals

A type of gasket suitable for use on hatches and windows combines the advantages of low leakage, long life, and easy replacement. The elastomer is subject to only moderate compression force and therefore lasts longer than a purely elastomeric gasket.
(See page 98)

ELECTRONIC PRESSURE SCANNERS

Compact, multi-channel devices provide a transducer-per-channel for gas and/or liquid pressure measurement. Users get a single, rugged, mountable package for multiple pressure measurements–without having to buy separate transducers. Save money, space and time. ESP-16BP scanners handle gas pressure measurements in harsh environments and are available with 8 or 16 channels. ESP-4AM scanners provide 4 channels for measurement of liquid pressure or high-pressure gases. PSI, 800-678-SCAN.

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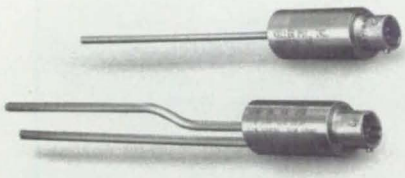

CRYOGENIC PRESSURE SENSORS

Compact, rugged pressure sensors measure liquids or gases at temperatures from ambient down to 1.5° Kelvin (-272°C). Sensors available for pressure ranges from 0-31 through 0-500 psi for absolute or differential pressures. Power dissipation is typically less than 6 mW. Sensors can be installed or even submerged within cryogenic systems. Factory calibration at cryogenic temperatures ensures high accuracy between 1.5° and 373°K. Available with digital readout and RS232 link. Keller-PSI, (619) 967-6066.

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SUBMERSIBLE DEPTH TRANSDUCERS

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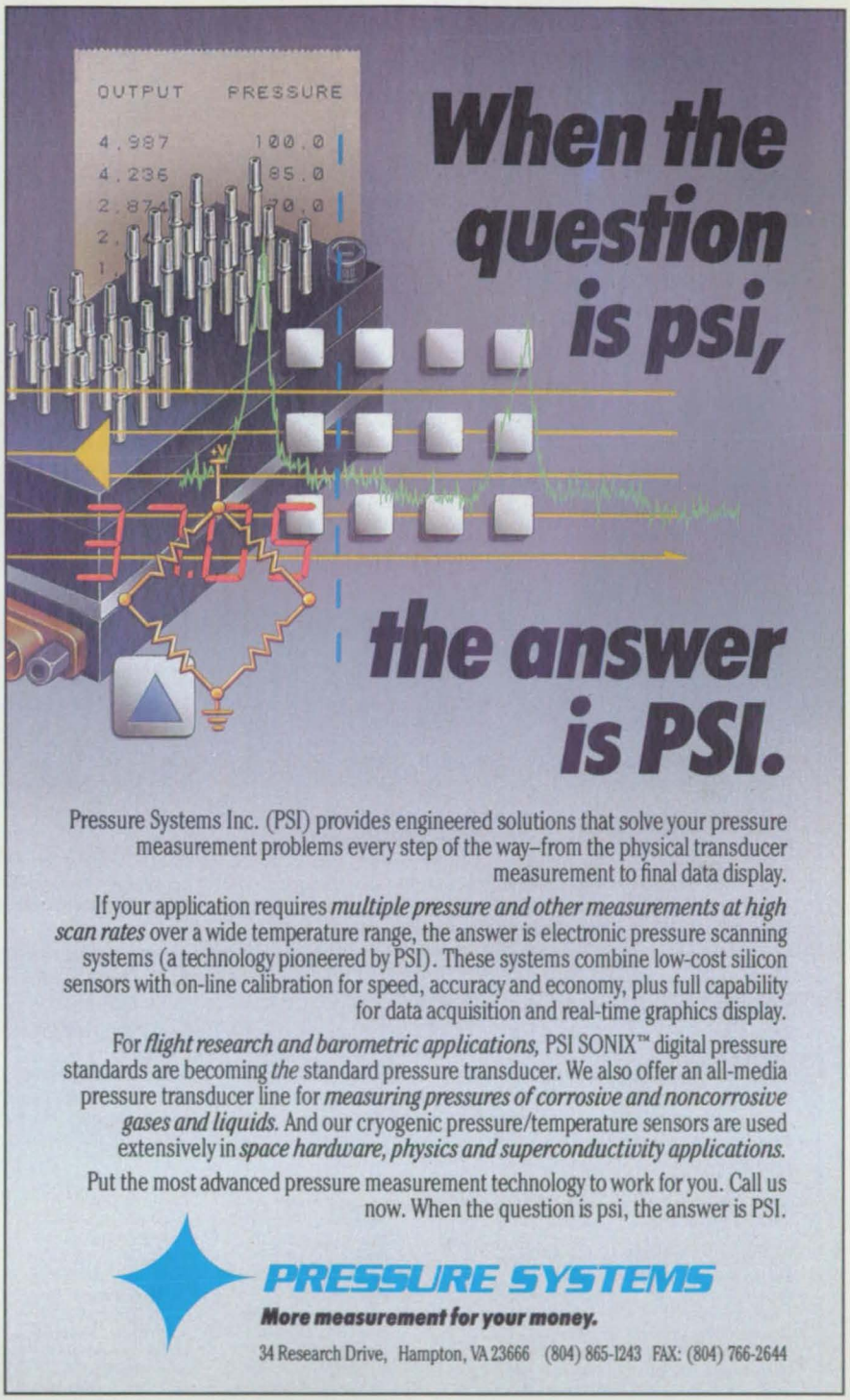

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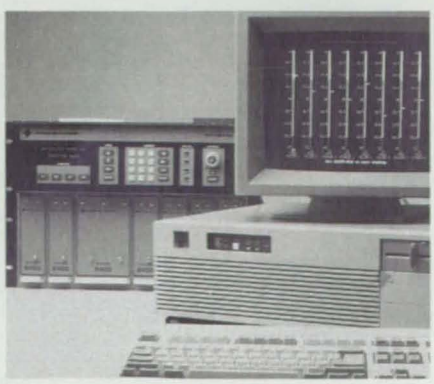

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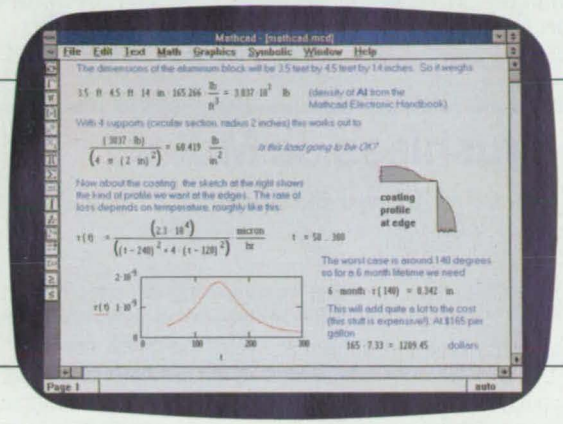

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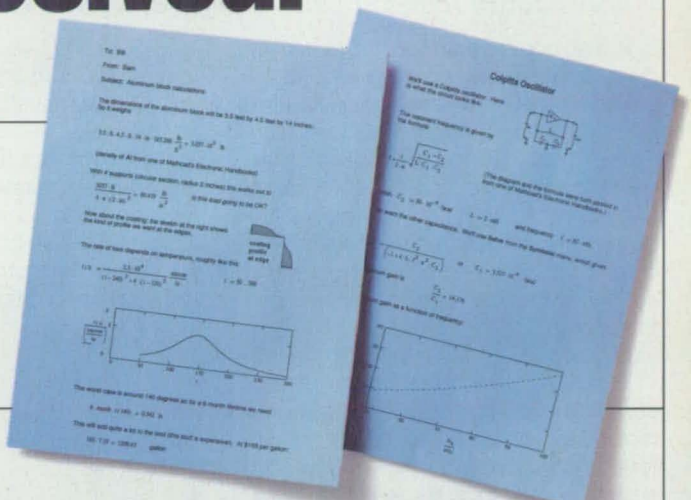

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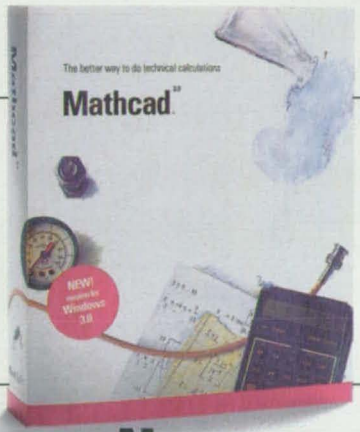

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Circle Reader Action No. 682

Electronic Components and Circuits

Pulse-Width-Modulating Driver for Brushless dc Motor

The power supply for the motor is electrically isolated from other power supplies.

NASA's Jet Propulsion Laboratory, Pasadena, California

A high-current pulse-width-modulating driver for a brushless dc motor features optical coupling of the timing signals from its low-current control circuitry to its high-current motor-driving circuitry. This optical coupling makes it possible to provide high electrical isolation of the motor-power supply, thereby helping to prevent the fast, high-current motor-driving pulses from being coupled through the power supplies into the control circuitry, where they could interfere with the low-current control signals.

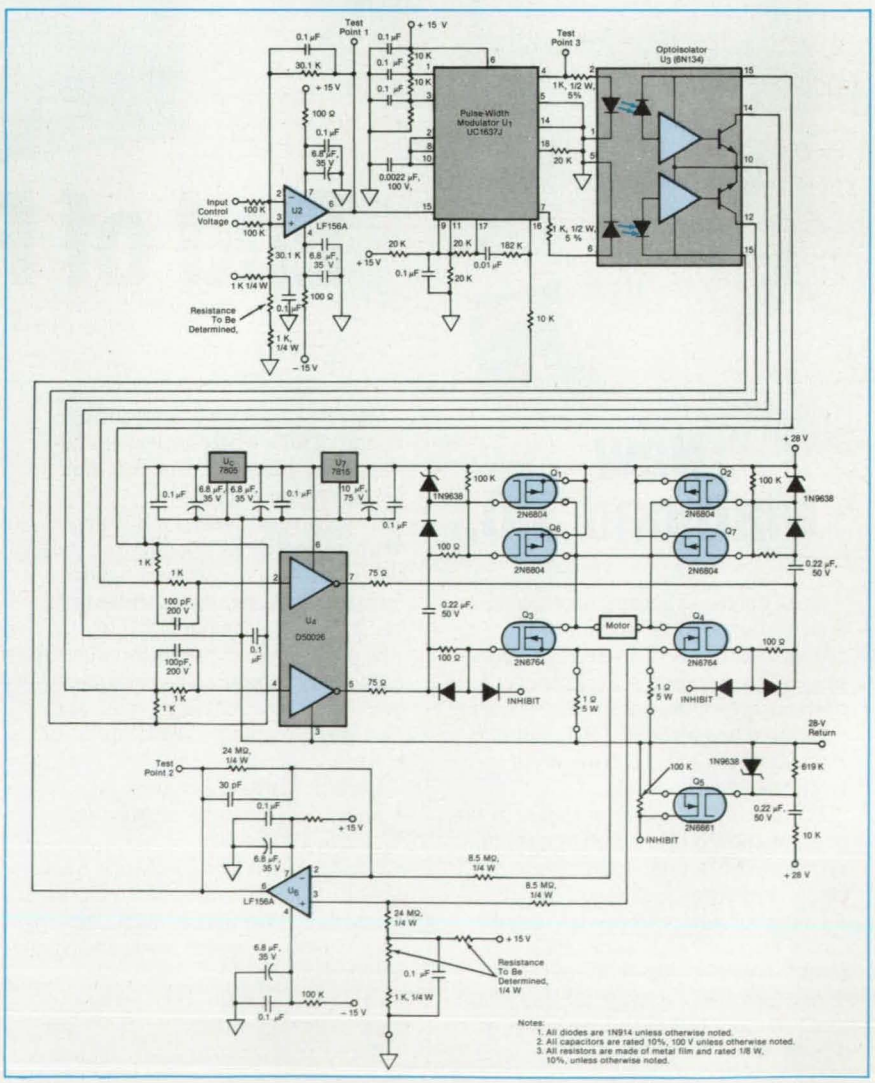
The driver (see figure) controls motor current by varying the duty cycle of the motor-drive voltage. Null or zero motor current results when the motor-drive-voltage waveform exhibits a 50 percent duty cycle. The direction and magnitude of net motor torque is determined by the duty-cycle variation about the 50 percent point. The motor is connected to its power supply via an H-bridge circuit of n-channel, enhancement-mode power, metal oxide/semiconductor field-effect transistors (MOSFET's) and p-channel power MOSFET's. By use of these two types of MOSFET's, each type connected in the polarity opposite that of the other type, it is possible to simplify the power-MOSFET-gate-driving part of the circuit in that it becomes unnecessary to supply a gate-driving voltage in excess of the supply voltage (as would be necessary if the H-bridge circuit contained all n-channel power MOSFET's).

The input control voltage is received differentially by amplifier U_2, which is capable of operating over the full ±10-V range of the input signal. The pulse-width-modulator circuit U_1 compares the input voltage (scaled through U_2) to a voltage proportional to the motor current (scaled through instrumentation amplifier U_5, as described more fully below). U_1 varies the duty cycle in such a way as to reduce the comparison (difference) voltage to zero.

The output of U_1 is optically isolated from the output transistor stages by optoisolator U_3, which couples signals through an optical link only. The output of U_3 is inverted by inverting buffer U_4, which generates the gate-driving voltages for the power MOSFET's of the H-bridge (Q_1 through Q_4, Q_6, and Q_7). Transistor Q_5 delays the turn-on of these MOSFET's until the gate-voltage waveforms have stabilized.

U_5, which operates in a balanced differential configuration, provides feedback voltage proportional to the motor-driving current. The use of two 8.25-MΩ resistors to couple the current signal to U_5 provides a net isolation of more than 4 MΩ for the motor-driving circuitry. In keeping with the concept of isolation of the high-current stages of the driver, separate voltage regulators are provided for the circuits associated with the output H-bridge.

This work was done by Phil M. Salomon of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 131 on the TSP Request Card.*
NPO-17142



The **Pulse-Width-Modulating Driver** features optical coupling of the timing signals (for electrical isolation of the motor and its power supply) and a complementary power-MOSFET H-bridge output circuit (to simplify the H-bridge-gate-driving circuitry).

Circuit Detects Faint Flashes Against Bright Background

The rapidly varying component of a luminous-flux signal is extracted from the total signal.

Marshall Space Flight Center, Alabama

An electronic circuit detects flashes of light against a bright background in a camera or telescope image. The circuit was designed to detect lightning from a spacecraft in orbit far above the clouds. Usually, the sunlight reflected from the clouds makes lightning invisible to an observer in orbit. The circuit could also be used on Earth to detect lightning from a distance during the day or night, or to detect other flashes of light in safety-related, scientific, industrial, and military applications.

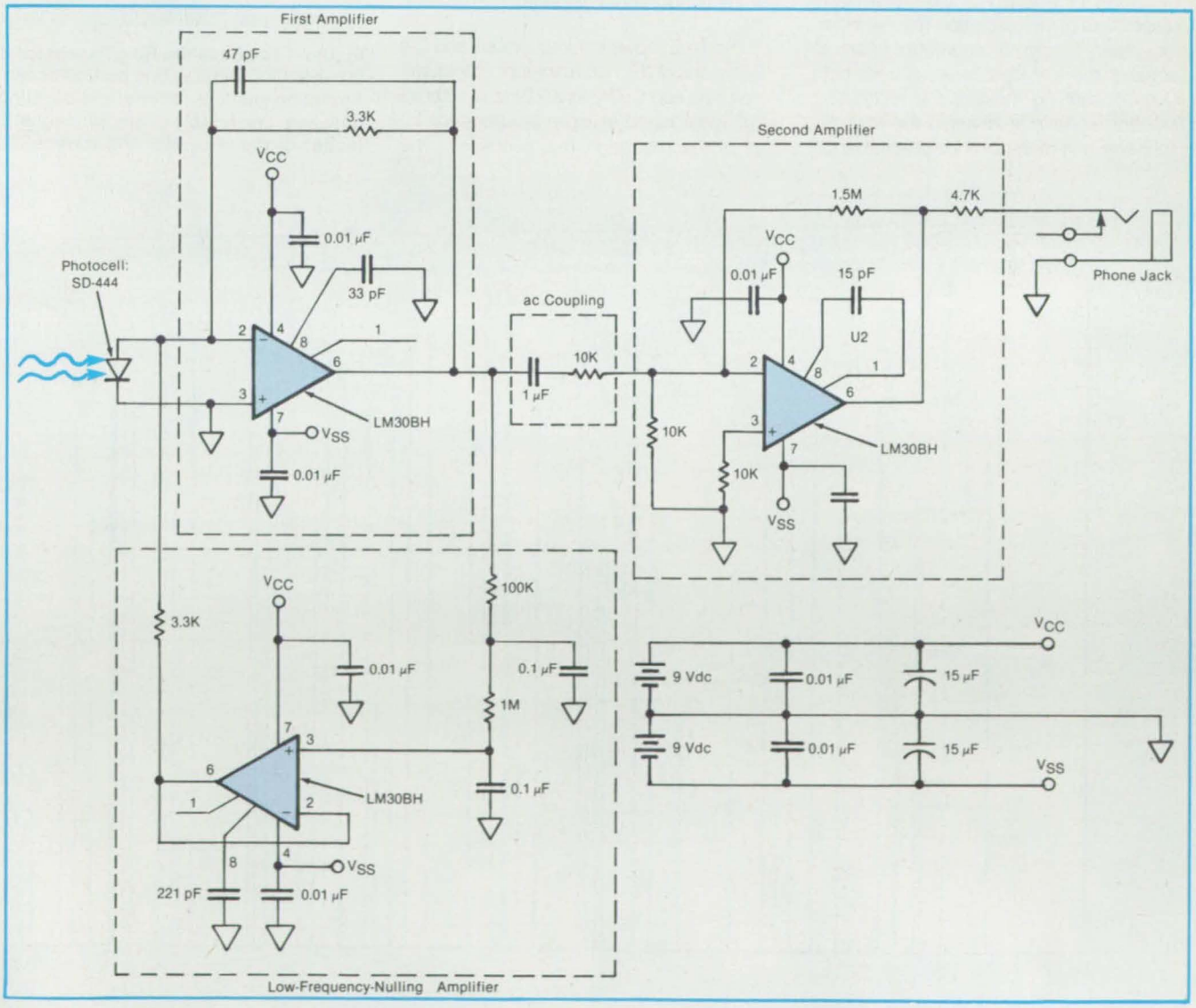
The circuit (see figure) includes the photocell that measures the luminous flux in the scene under observation. The output of the photocell includes a rapidly varying component that represents the lightning or other flash, plus a slowly-varying component that represents the slowly changing reflection of sunlight from the moving clouds or other bright background. The output of the photocell is fed to a first amplifier, which produces an inverted signal. The output of the first amplifier is fed back to its input via a low-pass filter and a noninverting amplifier.

Together, the low-pass filter and noninverting amplifier act as a low-frequency-nulling amplifier in that the feedback signal suppresses the low-frequency background signal at the input terminal of the first amplifier. Thus, the net output of the first amplifier consists mostly of the rapidly-varying flash signal. This output is sent to a second amplifier, where its amplitude is raised to about 150 times that of the input rapidly varying signals.

The output of the second amplifier is sent to a pair of earphones for aural monitoring and/or recorded on one track of a magnetic tape for future analysis. A time-base signal is recorded on the other track of the tape so that the time of each lightning pulse or other flash can be determined. A microphone can also be used to record verbal annotation on the tape.

A typical lightning pulse may appear as a single flash but usually consists of several strokes in rapid succession. The circuit can detect individual strokes, which have optical rise times of about 0.1 to 0.5 ms.

This work was done by O. Vaughan, M. L. Curtner, and D. Yeates of **Marshall Space Flight Center**. *For further information, Circle 63 on the TSP Request Card. MFS-28466*



The **Lightning Detector** is a photocell-and-amplifier circuit that detects flashes of light against a steady or slowly varying bright background. The low-frequency-nulling amplifier is part of a feedback loop that suppresses the low-frequency background signal.

Sapphire Ring Resonator for Microwave Oscillator

Phase noise is reduced to a new low.

NASA's Jet Propulsion Laboratory, Pasadena, California

A sapphire dielectric ring resonator operating in a "whispering-gallery" mode helps to stabilize the frequency and phase of a microwave oscillator. Although microwave carrier signals can be obtained by frequency multiplication of the outputs of quartz-crystal oscillators operating at 5 to 10 MHz, the resulting signals (typically at frequencies of tens of gigahertz) contain too much phase noise to be useful in some radio-science measurements. The new resonator reduces the phase noise appreciably at room temperature and promises unprecedented stability of phase at cryogenic temperatures.

The stabilizing effect is the result of the high Q (2π times the average electromagnetic energy stored divided by the energy dissipated per cycle of oscillation — a measure of the quality or sharpness of the resonance) of the resonator. The "whispering-gallery" type of operation helps to achieve the low loss necessary for high Q by containing most of the resonating electromagnetic field within the low-loss sapphire ring material via a phenomenon similar to total internal reflection in optical devices. Outside the sapphire ring, the evanescent field decays approximately exponentially with distance from the surface of the ring. Thus, by keeping as much of the ring as possible as far as possible from lossy metal components, the overall loss can be kept small.

Figure 1 shows the resonator installed for testing, including input and output waveguide ports on the axis of the sapphire ring and container. The axial length (height; z dimension) of the sapphire ring was chosen to be twice the radial (r dimension) thickness, for a principal (lowest-frequency) family of modes with electric fields polarized in the z direction. This choice enabled effective coupling to the principal modes by virtue of similar configurations of the fields in the waveguide and resonator.

Figure 2 shows the frequencies and Q's for modes of the ring resonator at frequencies between 5 GHz and 9 GHz. Q's above 10^5 were found at room temperature for all of the modes in this sequence. The

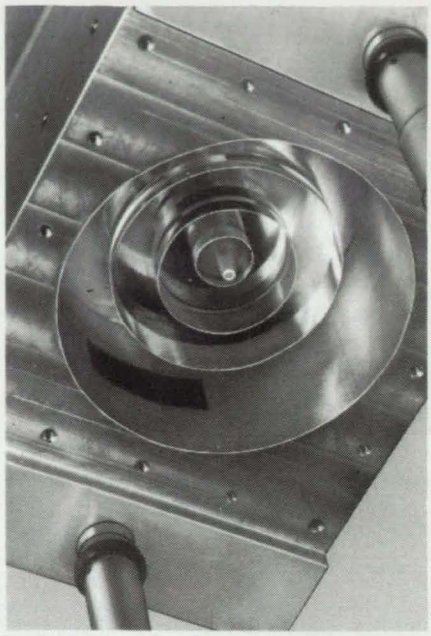


Figure 1. The **Sapphire Ring Resonator** is mounted for testing. This particular configuration provides for effective coupling between the principal electromagnetic modes of the resonator and waveguide.

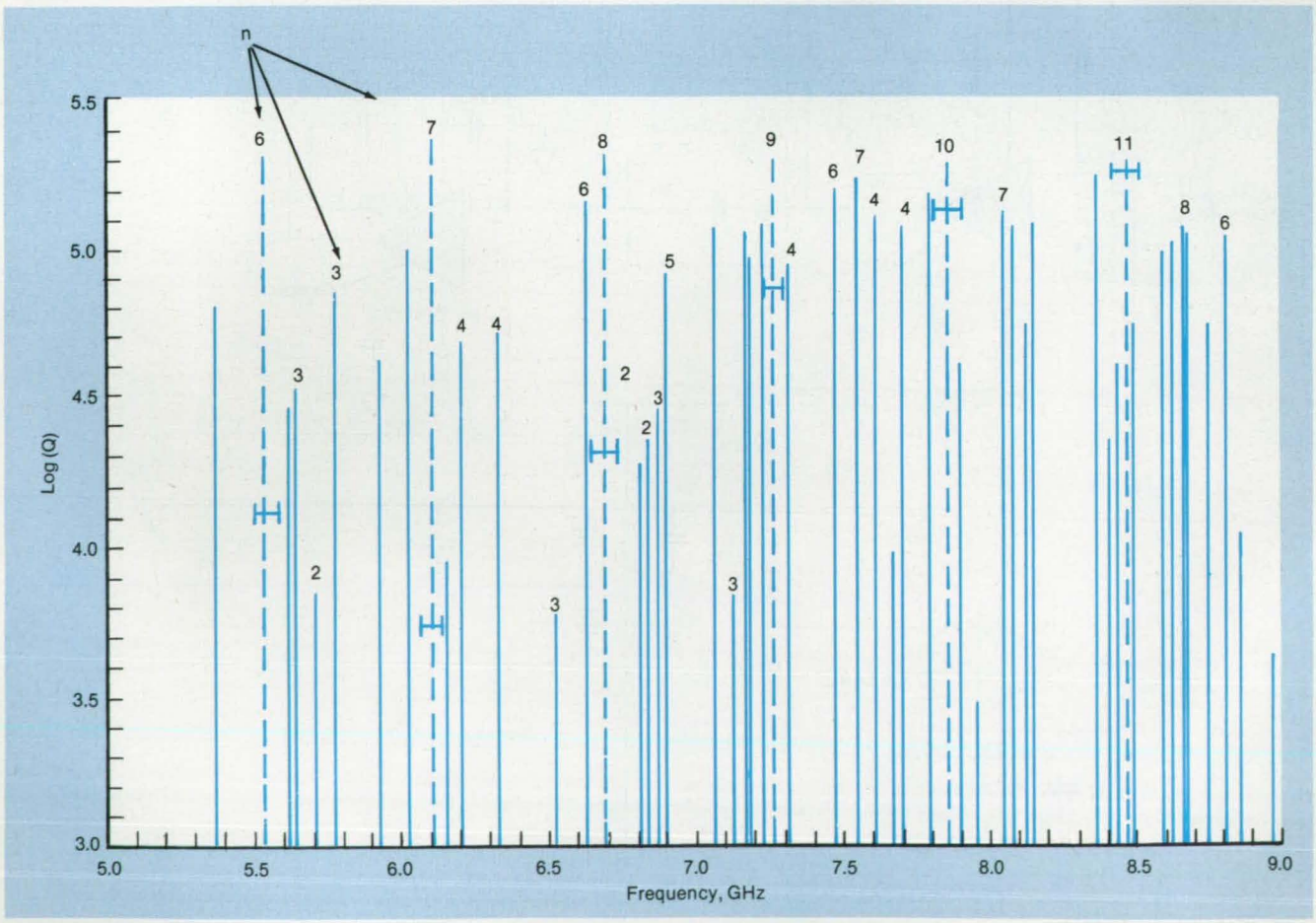


Figure 2. The **Q of the Resonator** was measured in the setup of Figure 1 at various frequencies from 5 to 9 GHz. For each "whispering-gallery" mode of the resonator, n denotes the number of wave periods around the circumference of the ring.

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measured phase noise of a transistor oscillator locked to the $n = 10$ (7.84-GHz) mode showed a $1/f^3$ dependence at low f (where f = the offset from the carrier frequency), and a value of -55 db/Hz at an offset of 10 Hz from the carrier. This appears to be lower than the phase noise previously reported for a noncryogenic X-band oscillator.

On the basis of these measurements and the performance of commercially available phase detectors, the phase noise of a resonator cooled to 77 K and with a Q of 3×10^7 is projected to be -85 dB/Hz at an offset of 1 Hz. This value is 30 dB below that of a frequency-multiplied quartz-crystal oscillator that is the best X-band source now available.

This work was done by G. John Dick and Jon Saunders of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 57 on the TSP Request Card.*
NPO-18082

GaAsP Photodiodes as X-Ray Detectors

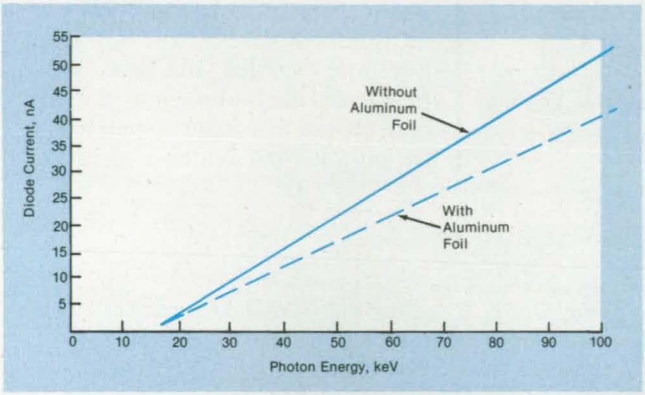
GaAsP cells cost less than Si cells do and are less damaged by radiation.

NASA's Jet Propulsion Laboratory, Pasadena, California

Tests show that commercial G1126-02 GaAsP photodiodes designed as ultraviolet detectors can be modified easily for use as x-ray detectors. At present, x-ray and other highly energetic radiation are usually measured with specially fabricated silicon cells. The modified GaAsP photodiodes cost about one third as much as the silicon cells and are more resistant to damage by radiation.

The GaAsP photodiodes have quartz windows. When used to measure ultraviolet fluxes, the windows or other apertures in the optical paths are covered with optical filters. To modify one of these photodiodes for the x-ray application, one removes the quartz window and replaces it with an aluminum foil, which blocks ultraviolet and visible radiation.

To verify the concept, GaAsP cells were tested with quartz windows, without window covering, and with windows of aluminum foil 1 mil (0.025 mm) thick. The figure presents the results of one of the tests, showing that the tested photodiode does indeed function as a detector of photons with energies from 20 to 100 keV.



The **Approximate Relative Spectral Responsivity** of a GaAsP photodiode with and without an aluminum-foil window indicates that the aluminum foil can be used to block visible and ultraviolet light and that the photodiode can detect x rays that penetrate the foil.

This work was done by Eric G. Laue of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 3 on the TSP Request Card.*
NPO-17849

Hole-Impeded-Doping-Superlattice LWIR Detectors

Detectors would operate at wavelengths up to 17 μm and temperatures above 65 K.

NASA's Jet Propulsion Laboratory, Pasadena, California

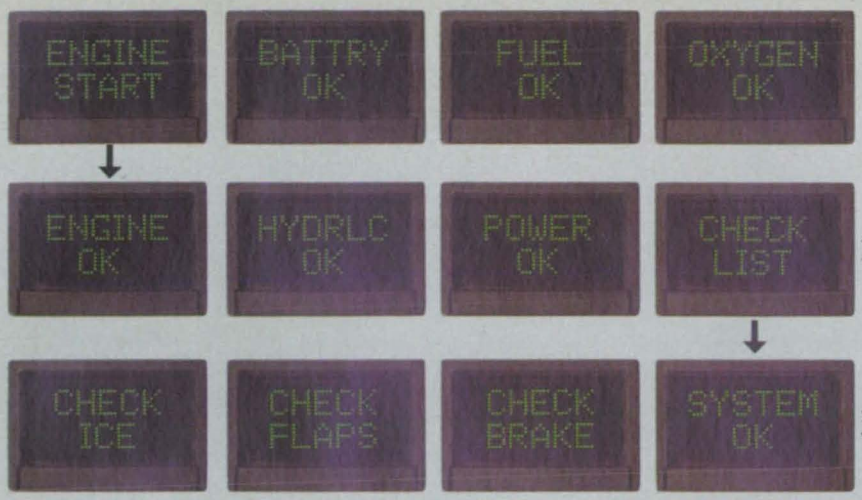
Hole-Impeded-Doping-Superlattice (HIDS) InAs devices have been proposed for use as photoconductive or photovoltaic detectors of radiation in the long-wavelength infrared (LWIR) range of 8 to 17 μm. There is scientific and military demand for arrays of such devices for imaging and spectroscopy, which would be compatible with silicon multiplexing and readout circuitry and which could operate at temperatures above 65 K. Prior silicon LWIR detectors have required cooling to temperatures below 12 K, and recent AlGaAs/GaAs quantum-well LWIR detectors have lower sensitivity and require deflection of light into the planes of the semiconductor wafers, making development into imaging arrays more difficult.

The HIDS concept is based on the growth of narrow-band-gap semiconductors from groups III and V of the periodic table to form a superlattice with a doping profile that provides long-wavelength cutoff and impedes the interlayer hole conductance. Extrapolating from experience with GaAs devices (which operate at wavelengths of about 1 μm), the proposed devices would be fabricated by molecular-beam epitaxy (MBE) of doped InAs on Si or GaAs substrates.

The upper part of the figure illustrates a portion of an array of the proposed HIDS devices, and the lower part of the figure shows typical doping and energy-level profiles. The spatially oscillating doping profile would cause the electron and hole potentials to oscillate correspondingly in such a way as to reduce the energy gap, E_g, between the valleys in the conduction band and the peaks in the valence band. This gap would depend on the concentrations of dopants and the thicknesses of the layers and could be tailored to any value (to obtain the desired cutoff wavelength) from zero to the E_g of undoped InAs. The oscillating profile would also cause separation of the peaks of the electron and hole wave functions; this effect is undesired in that it would reduce the absorption of the infrared photons of interest, but it could be kept within acceptable limits by use of high concentrations of dopants and, within these limits, would be offset by the beneficial effect of increased carrier lifetime. Optimization of the doping profile may be achievable with modern "delta" sheet doping techniques during MBE growth.

In the face of the impracticality of matching the concentrations of electron-donor (n) and electron-acceptor (p) dopants precisely in the n^+ and p^+ layers, respectively, it is beneficial to impede the conductivity for holes along the z axis (perpendicular to the planes of the layers). This would be done by making the barriers to holes (n^+ layers) sufficiently thick. The small effective mass of electrons and thinner barriers to electrons (p^+ layers) allows electrons to penetrate perpendicularly to the layers fairly freely with good mobility, thus permitting minority carrier electron collection at the n^+ contact layer. Although the smaller effective masses of the electrons (in comparison with the effective masses of the holes) would give rise to undesired greater quantization of energy levels in the electron-potential wells, this effect would be reduced by the greater thicknesses of the electron-potential wells (which coincide with the hole-potential barriers).

The upper figure illustrates either a photovoltaic or photo conductive detector, de-



AN APPLICATIONS EXAMPLE. While the following example is for aircraft, it could apply to any air, land, sea or space system.

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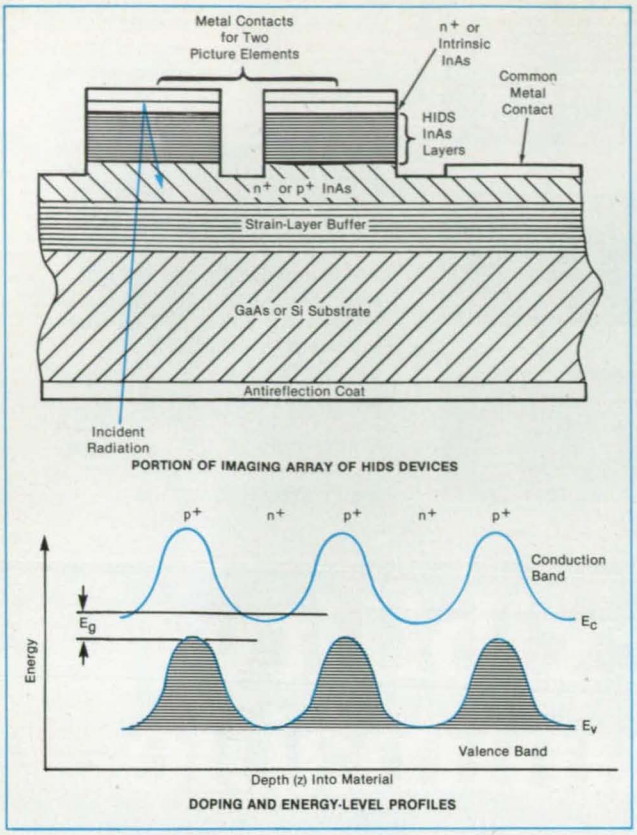


An **Array of HIDS Devices** would be fabricated on a substra GaAs or Si. Radiation would be incident on the back surface, the metal contacts for the picture elements would serve as re tors, effectively doubling the optical path and thereby increasin absorption of photons.

pending on whether the lower InAs contacting layer is p^+ or n^+, respectively. It would also be desirable to grow a p^+ GaAs layer over the exposed etched grooves to provide surface passivation and improved hole contact. The photoconductive detector offers advantages of high gain and high impedance; the photovoltaic detector offers lower noise and a better interface to multiplexer readouts.

This work was done by Joseph Maserjian of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 51 on the TSP Request Card.*

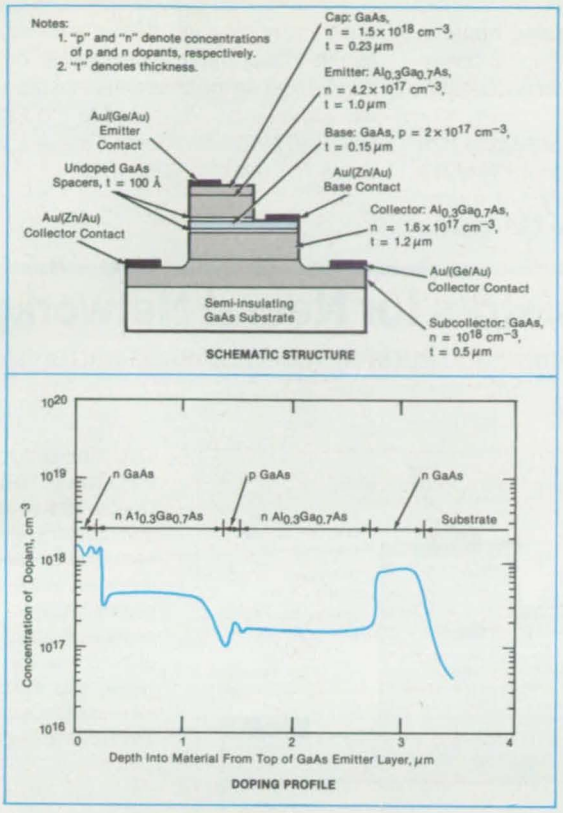
This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office-JPL [see page 16]. Refer to NPO-17880.

High-Gain $Al_xGa_{1-x}As$/GaAs Transistors for Neural Networks

Darlington pairs exhibit current gains of 4,000.

NASA's Jet Propulsion Laboratory, Pasadena, California

High-gain $Al_xGa_{1-x}As$/GaAs npn double heterojunction bipolar transistors have been developed for use as phototransistors in optoelectronic integrated circuits, especially in artificial neural networks. In the contemplated optoelectronic implementation of a neural network, a two-dimensional array of photodetectors, saturating amplifiers, and light sources would be integrated on a monolithic circuit chip. Each light source would represent the output of a neuron; the light would be diffracted to



This **$Al_xGa_{1-x}As/GaAs$ npn Double-Heterojunction Bipolar Transistor** was grown epitaxially by metal-organic chemical-vapor deposition. The concentration of dopant was measured by an electrochemical profiler.

other neurons by holographic optical elements. When the total optical input to a neuron was below a threshold level, the output of the neuron would be zero. When the total input exceeded that level, the output of the neuron would rise to a saturation value. $Al_xGa_{1-x}As/GaAs$ double-heterojunction bipolar transistors would perform both the photodetection and saturating-amplification functions of the neurons. These transistors are good candidates for such an application because they are structurally compatible with laser diodes and light-emitting diodes, can detect light, and can provide the high current gain needed to compensate for losses in the holographic optical elements.

The developed transistors (see figure) were grown epitaxially by metal-organic chemical-vapor deposition on semi-insulating substrates of (100)-oriented GaAs doped with Cr. The GaAs and $Al_xGa_{1-x}As$ layers were grown from $Ga(CH_3)_3$, $Al(CH_3)_3$, and AsH_3 gases in H_2 carrier gas. The p and n dopants were Zn and Si, respectively. During the growth of the layers, the temperatures of the substrates were maintained at about 730°C.

To obtain large current gain, it was necessary to suppress diffusion of Zn out of the base layer during the deposition process. A reduction in the deposition temperature would have had this effect but would also have resulted in a greater number of undesired nonradiative recombination centers in the light sources that would eventually be integrated with the transistors. The nonradiative recombination centers will significantly degrade performance of the light sources. Therefore, to reduce the out-diffusion of Zn, the concentration of Zn was reduced below what would otherwise be considered normal for transistors of this type. In general, a reduction in the base doping causes an increase in the base resistance and a consequent increase in the

switching time of the transistors. However, in a neural network, even a relatively long switching time of 1 μs is acceptable.

In tests of electrical characteristics, a transistor of the new type exhibited a common-emitter current gain of 500. A wire-connected pair of such transistors in the Darlington configuration exhibited an overall current gain of 4,000, which more than satisfies the estimated requirement of 2,500 for an optoelectronic neural network. An experimental monolithic 10×10 array of optoelectronic neurons was built, and the fully functional operation of the neuron arrays was successfully demonstrated.

This work was done by Jae-Hoon Kim and Steven H. Lin of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 22 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office-JPL [see page 16]. Refer to NPO-18101.

Alternative $Al_xGa_{1-x}As$/GaAs Transistors for Neural Networks

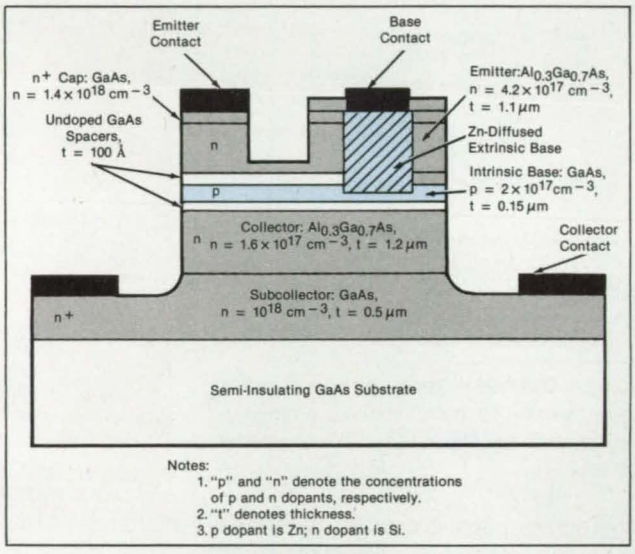
Current gain is increased through reduction of bulk leakage and surface-recombination currents.

NASA's Jet Propulsion Laboratory, Pasadena, California

Further development efforts have yielded an alternative version of the transistors described in the preceding article, "High-Gain $Al_xGa_{1-x}As$/GaAs Transistors for Neural Networks" (NPO-18101). These efforts have focused on determining the effects of various aspects of the design and of the fabrication processes upon leakage currents and, consequently, on current gains.

It is difficult to obtain high and reproducible current gains in double-heterojunction bipolar transistors with bases containing diffused zinc like those of the preceding article largely because such transistors have leakage currents much greater than those of the more-conventional etched-base double-heterojunction bipolar transistors. The leakage currents are mainly caused by recombinations of charge carriers in the depletion regions, in the bulk regions, and on the surfaces. Furthermore, the diffusion of the Zn dopant out of the base region at the high fabrication temperatures can destroy the integrity of the emitter-base heterojunction.

The figure shows the alternative transistor configuration. Research on the aforementioned and other factors that affect current gains led to the conclusion that the current gain of such a transistor could be maximized by (1) reducing the leakage currents that flow laterally through the homojunction between the zinc-diffused extrinsic $Al_{0.3}Ga_{0.7}As$ base layer and the $Al_{0.3}Ga_{0.7}As$ emitter layer, (2) reducing the thermal degradation, during fabrication, of minority-carrier lifetime in the base, and (3) optimal control of the diffusion of Zn as a function of temperature and time during fabrication.



This **Zinc-Diffused-Extrinsic-Base Double-Heterojunction Bipolar Transistor** differs from the one described in the preceding article in the design and fabrication of the connection between the external metal contact and the intrinsic base layer.

Specifically, the lateral leakage currents can be suppressed by etching an isolating channel between the emitter and extrinsic base regions. The highest current gain is obtained when the channel is etched to a depth that leaves a depleted $Al_{0.3}Ga_{0.7}As$ emitter layer about 1,000 Å thick covering the intrinsic base layer. The reason is that at this optimal etching depth, the surface-depletion layer and the intrinsic base-emitter-junction-depletion layer can punch through and the leakage currents are effectively blocked from the emitter periphery. This layer acts as a passivation layer and reduces the surface-recombination currents aw well. The depth of diffusion of zinc to form the extrinsic base layer is controlled accurately so that it reaches the base layer and so that the diffusion process causes minimal degradation of the minority-carrier lifetime in the intrinsic base layer.

Specimens of the transistors exhibited dc common-emitter current gains as high as 200. With further improvements in design and processing, it may be possible to obtain gains comparable to those of the etched-base transistors. A monolithically integrated Darlington pair of such transistors exhibited an overall current gain of 6,000.

This work was done by Jae-Hoon Kim and Steven H. Lin of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 6 on the TSP Request Card.* *NPO-18177*

High-Power AlGaAs Quantum-Well Lasers on Si Substrates

Improved devices are made by migration-enhanced molecular-beam epitaxy and metalorganic vapor-phase epitaxy.

NASA's Jet Propulsion Laboratory, Pasadena, California

$Al_xGa_{1-x}As$ lasers of the graded-index-of-refraction, separate-confinement-heterostructure, single-quantum-well type have been fabricated on silicon substrates by migration-enhanced molecular-beam epitaxy followed by metalorganic vapor-phase epitaxy. These lasers are intermediate products of a continuing effort to develop low-threshold-current, high-efficiency lasers for parallel optical interconnections between large-scale optoelectronic integrated circuits.

Figure 1 illustrates the composition-vs.-depth profile of one of these lasers. The initial (leftmost in this figure) layer of GaAs

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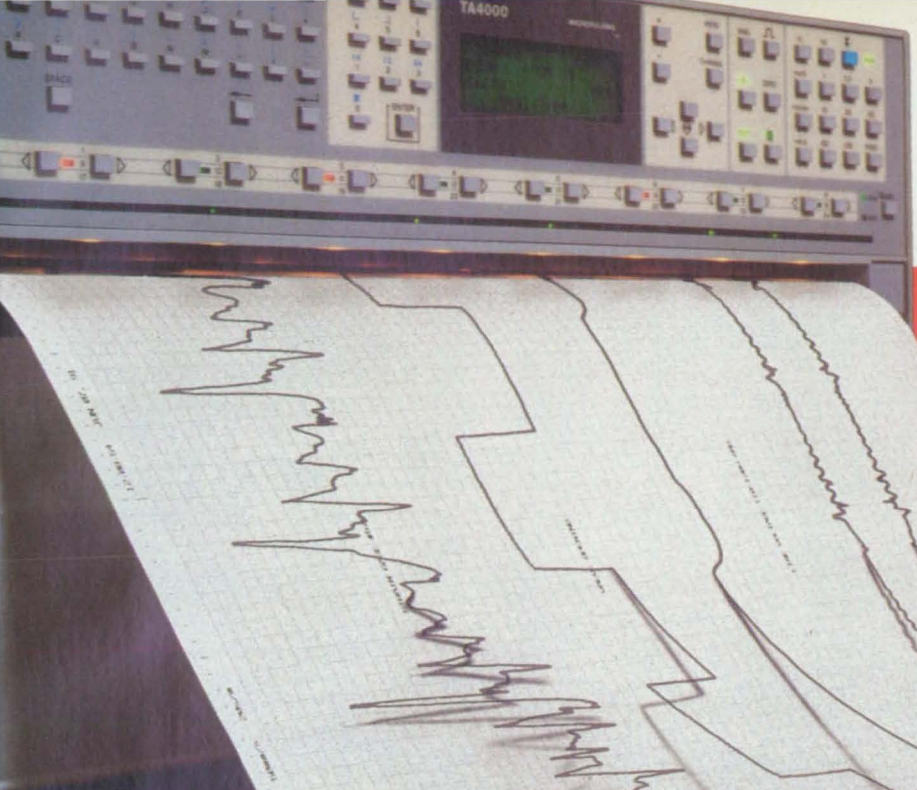

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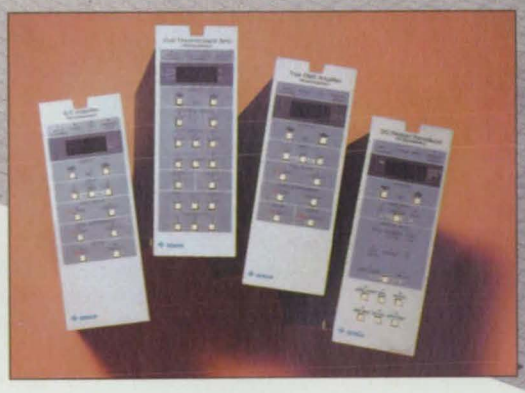

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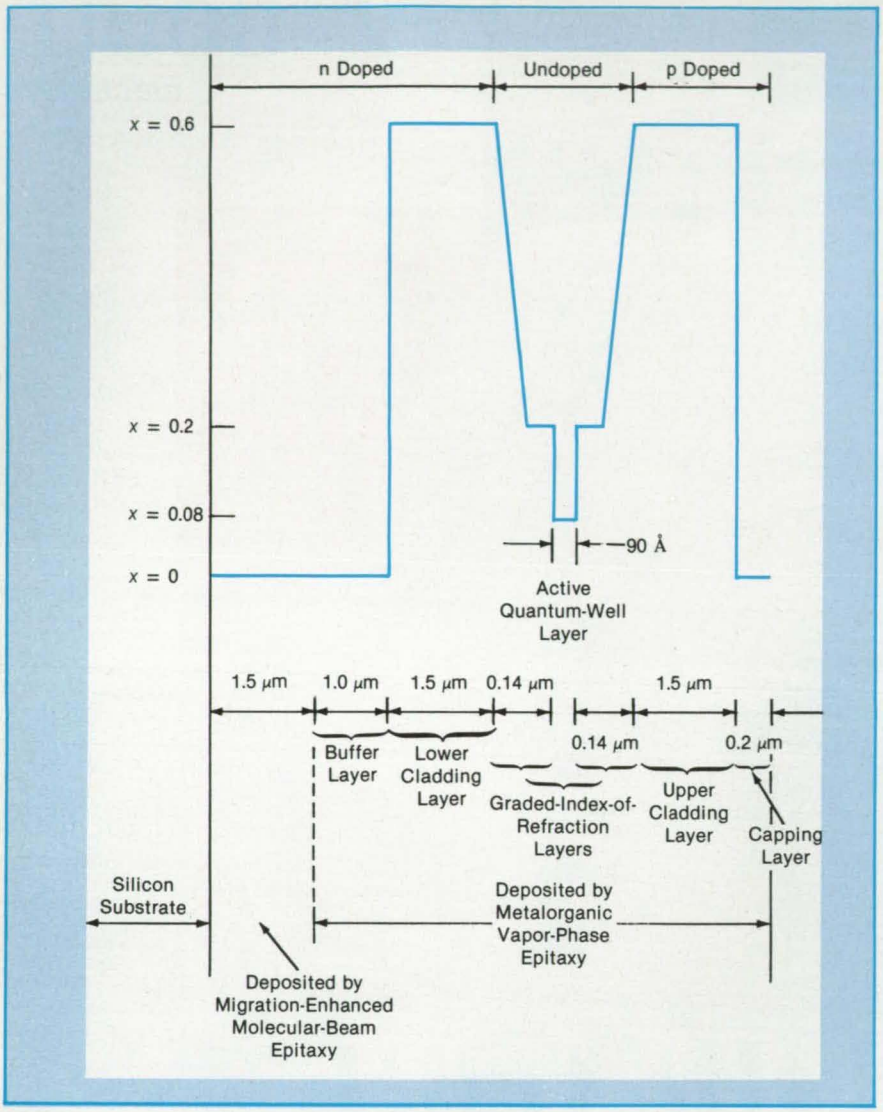


Figure 1. The **Atomic Fraction, *x*, of Aluminum** in $Al_xGa_{1-x}As$ is plotted as a function of distance (decreasing depth) from the surface of the Si substrate.

doped with silicon (n dopant) was grown by migration-enhanced molecular-beam epitaxy on an n-doped silicon (100) substrate tilted 4° toward the [110] direction. In this particular version of migration-enhanced molecular-beam epitaxy, two sublayers of the initial GaAs layer were deposited in the following sequence:

1. The first 150 monolayers of GaAs were grown by migration-enhanced molecular-beam epitaxy, in which Ga and As beams were supplied alternately and the substrate was heated to ≲400 °C — less than the conventional molecular-beam-epitaxy temperature of ≳580 °C — to reduce the density of defects.
2. The second sublayer, 1.5 to 2.0 μm thick, was grown by molecular-beam epitaxy that was conventional in that Ga and As beams were supplied simultaneously but unconventional in that the temperature was kept ≲400 °C.

The $Al_xGa_{1-x}As$ layers of the graded-index-of-refraction, separate-confinement-heterostructure quantum well were deposited by metalorganic vapor-phase epitaxy at a temperature of 750 °C and a pressure of 76 torr (10 kPa). The sources of gallium, aluminum, and arsenic were trimethylgallium, trimethylaluminum, and arsine, respectively; the sources of the p dopant (zinc) and the n dopant (silicon) were diethylzinc and silane in hydrogen, respectively. The heterostructures thus deposited were fabricated into lasers by cleaning, polishing, deposition of metal contacts, and cleavage along the [011] direction to form the laser facets.

The lasers were tested and found to have excellent current-vs.-voltage characteristics that included sharp forward turn-on at 1.1 V and reverse breakdown at 8 V. Figure 2A shows the output power as a function of injection current of a laser with a cavity length of 500 μm and a stripe differential width of 110 μm, without coating on the facets, at room temperature. This plot indicates a differential quantum efficiency of 40 percent. It also indicates a 300-mA threshold current, which corresponds to a threshold current density of 550 A/cm² — considerably better than the 1- to 2-kA/cm² threshold-current density of prior $Al_xGa_{1-x}As$ lasers on Si substrates. In addition, the peak output power of more than 400 mW per facet may be the highest peak power observed to date on low-threshold-current lasers on Si substrates. The laser shows stable operation to more than 400 mW per facet at $6I_{th}$. The full width at half maximum of the farfield pattern in Figure 2B varies from 3° to 6° over the entire pumping range.

This work was done by Jae-Hoon Kim, Robert J. Lang, Gouri Radhakrishnan, and Joseph Katz of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 5 on the TSP Request Card. NPO-17988*

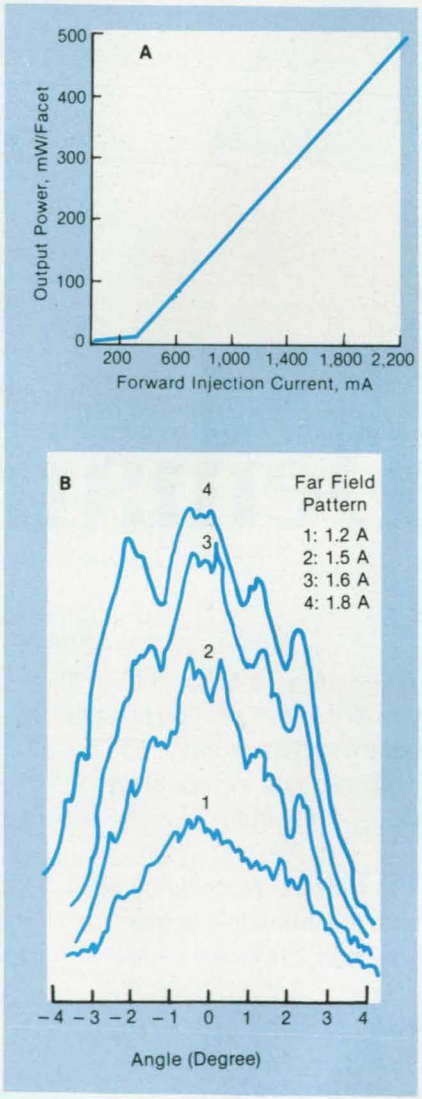


Figure 2a. The **Output vs. Injection Current** of a laser of the type described in the text indicates a differential quantum efficiency of 40 percent and a threshold current of 300 mA. Figure 2b. The Far-Field Patterns of a laser are plotted as a function of angle at different pumping levels.

Resistor Extends Life of Battery in Clocked CMOS Circuit

The circuit is operated at low power to reduce current drain.

NASA's Jet Propulsion Laboratory, Pasadena, California

The addition of a fixed resistor between a battery and a clocked complementary metal oxide/semiconductor (CMOS) circuit (see Figure 1) reduces the current drawn from the battery. This simple expedient can prolong the lives of batteries in such low-power CMOS circuits as watches and calculators.

The basic idea is to minimize the current drawn from the battery by operating the CMOS circuit at the lowest possible current consistent with the use of simple, fixed off-the-shaft components. The principle of operation is illustrated in Figure 2, which shows the nonlinear current-vs.-voltage characteristics of the circuit in question. The upper and lower curves denote the limits of unit-to-unit and thermal variations in these characteristics.

To provide enough power under worst-case conditions (the lower curve), it is necessary to set the battery voltage fairly high. As a result, the battery, which has low resistance, would initially drain at a rate greater than that required by the CMOS circuit unless a power-conditioning circuit of some kind were added. In this case, the fixed resistor (typically > 100 kΩ) in series with the battery acts as the power conditioner, allowing the CMOS circuit to effectively regulate its own operation to a lower voltage and current. When the battery is fresh, the operating point lies somewhere along the line between points C and D. When the battery is weak, the operating point lies on the line between points E and F.

Point F is the point of minimum operating current. Because this current is relatively low, the resistor has little effect near the end of the useful life of the battery; that is, even if the series resistor

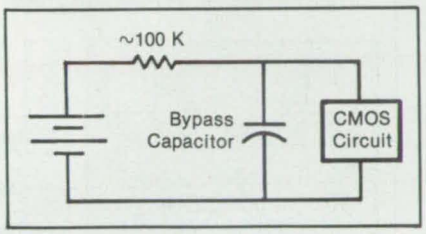


Figure 1. The **Resistor in Series With the Battery** reduces the current drawn by the CMOS circuit, thereby prolonging the life of the battery. The bypass capacitor smooths out operating transients.

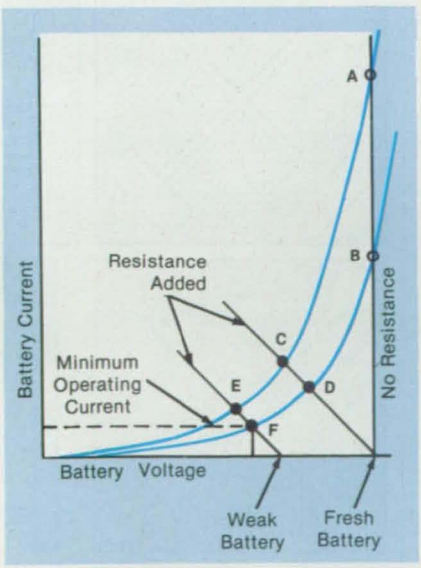


Figure 2. The **CMOS Circuit** operates at the intersection of the applicable straight line and the applicable nonlinear current-vs.-voltage characteristic. The current drain with resistance added is much less than it is without resistance added.

were shorted out once the current fell to the minimum, the current would soon fall to the minimum again.

This work was done by George H. Wells, Jr. of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 120 on the TSP Request Card.*
NPO-17967

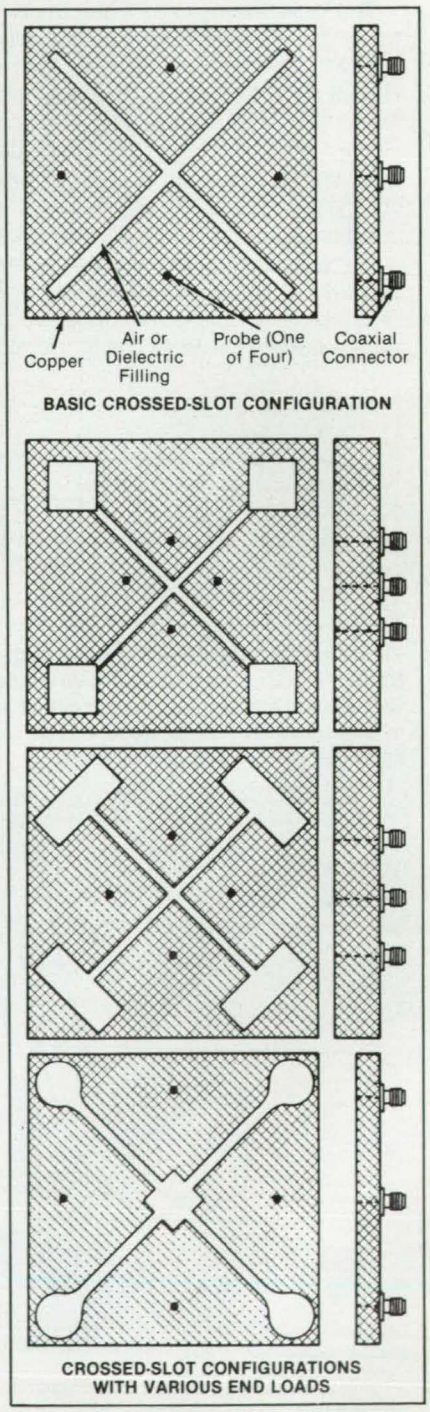
End-Loaded, Cavity-Backed, Cross-Slot Antennas

Advantages include lower losses, lighter weights, smaller sizes, and greater bandwidths.

NASA's Jet Propulsion Laboratory, Pasadena, California

End-loaded, cavity-backed, cross-slot antennas are being developed for use in the mobile/satellite service and other similar commercial services. These antennas are intended to transmit and receive in circular polarization at frequencies between 1 and 2 GHz. They can be fabricated and tuned to their operating frequencies fairly easily. In comparison with prior crossed-slot antennas, they weigh less, cost less, and exhibit lower electrical losses.

Crossed-slot antennas, including cavity-backed versions, have been used before.



Cavity-Backed Cross-Slot Antennas can be made without end loading or with end loading tailored to obtain various desirable electrical characteristics.

End loading has also been used before in antennas of other types to decrease the resonant lengths of radiating elements. In this case, the crossed-slot, cavity-backed and end-loaded-antenna concepts are combined to obtain the advantages of all three.

The figure illustrates cavity-backed cross-slot antennas both without end loading and with several different end-loading shapes. The feed lines are connected via four straight coaxial probes placed symmetrically at 90° intervals. Proceeding in a circle around the center, each probe is excited 90° out of phase with respect to the preceding probe. Because each pair of geometrically and electrically opposing probes lies in the null field of the other pair, cross-polarization is minimized. The center conductor of each probe is soldered to the top (slotted) plate of the cavity, while the outer conductor is soldered or otherwise fastened to the bottom plate.

The end loading (widening at the ends) increases the electrical length of a slot, thereby decreasing its resonant frequency (or, equivalently, making it possible to use a shorter slot to obtain a given resonant frequency). Thus, by use of end loading, one can make the antenna smaller (and, therefore, lighter in weight). Alternatively, one can exploit this effect to counteract the decrease in electrical length (or, equivalently, the increase in resonant frequency) that occurs upon removal of the dielectric filling from the cavity.

These antennas have very good radio-frequency characteristics. Antennas with air-filled cavities exhibit lower losses than do those with dielectric-filled cavities, and the elimination of the dielectric reduces weight. Moreover, air-filled-cavity antennas have larger bandwidths (lower voltage standing-wave ratios over wider frequency ranges) and, in comparison with antennas that contain low-loss dielectrics, are less expensive. These antennas do not require external tuning circuits, and the elimination of these circuits reduces both costs and electrical losses even further.

This work was done by Farzin Manshadi of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 88 on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

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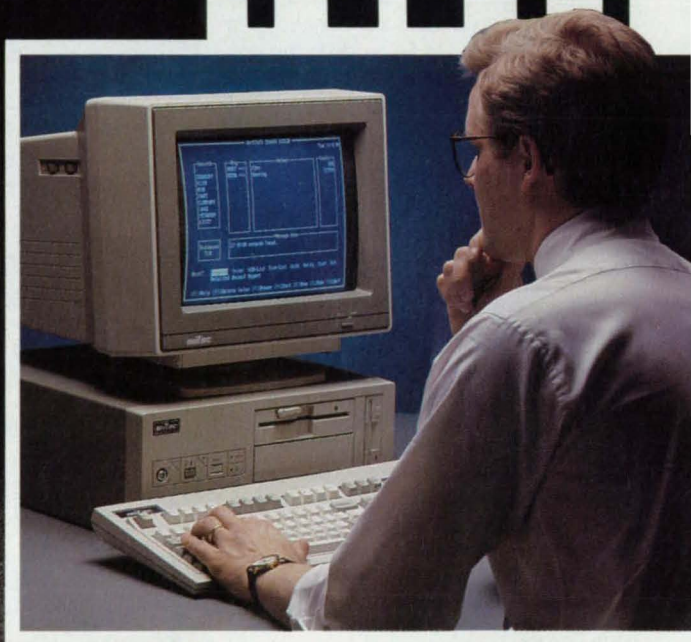

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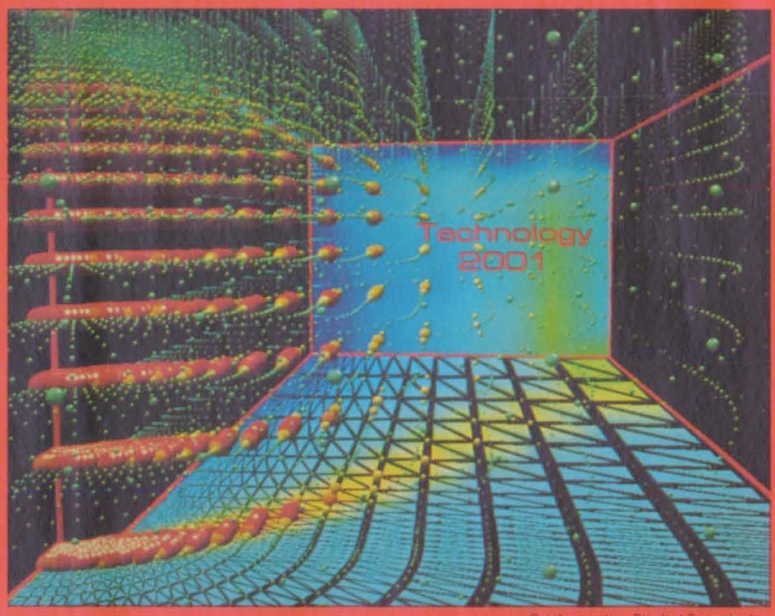

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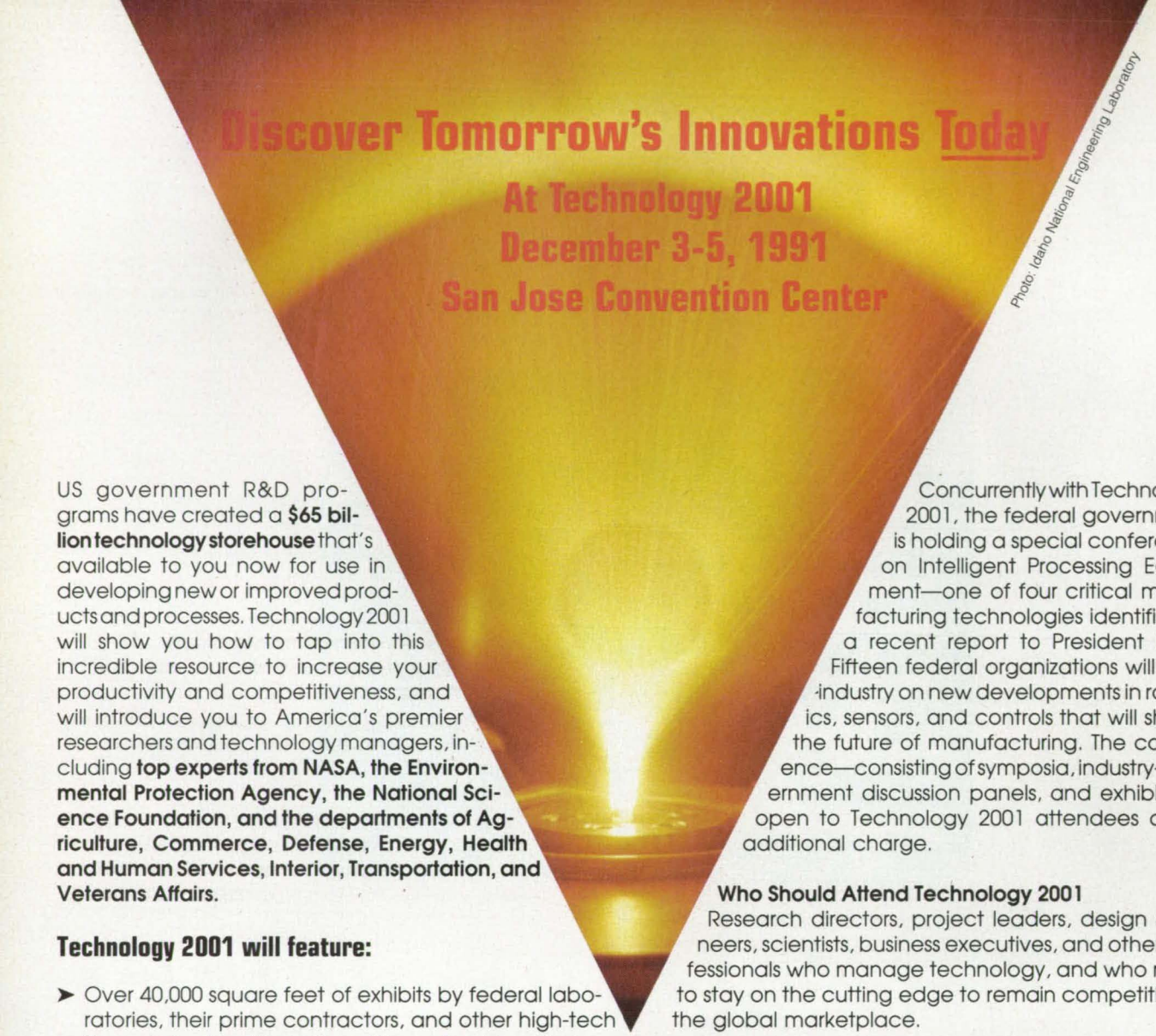

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Plus these special events:

- A Pre-Show Reception on Monday, Dec. 2 in the exhibit hall, offering attendees and the media the chance to preview the exhibits and meet the presenters in a relaxed, informal atmosphere;
- The second annual Technology Transfer Awards Dinner, recognizing outstanding achievements in tech transfer to industry. This event offers a unique opportunity to network with government and industry executives in an elegant setting—the Imperial Ballroom of the San Jose Fairmont Hotel. (Seating is limited, so reserve tickets early!)

Concurrently with Technology 2001, the federal government is holding a special conference on Intelligent Processing Equipment—one of four critical manufacturing technologies identified in a recent report to President Bush. Fifteen federal organizations will brief industry on new developments in robotics, sensors, and controls that will shape the future of manufacturing. The conference—consisting of symposia, industry-government discussion panels, and exhibits—is open to Technology 2001 attendees at no additional charge.

Who Should Attend Technology 2001

Research directors, project leaders, design engineers, scientists, business executives, and other professionals who manage technology, and who need to stay on the cutting edge to remain competitive in the global marketplace.

Do not miss this opportunity to access a wealth of federally-developed technology, meet the key players in government and high-tech industry, and discover tomorrow's innovations, today.

Show Schedule

Monday, Dec. 2	
6:00 pm - 8:00 pm	Opening Reception
Tuesday, Dec. 3	
9:00 am -10:30 am	Plenary Session
1:00 pm - 3:00 pm	Technical Sessions
4:30 pm - 6:00 pm	Govt./Industry Workshops
Wednesday, Dec. 4	
8:30 am -10:30 am	Technical Sessions
1:00 pm - 3:00 pm	Technical Sessions
4:30 pm - 6:00 pm	Govt./Industry Workshops
7:00 pm -10:00 pm	Awards Dinner
Thursday, Dec. 5	
8:30 am -10:30 am	Technical Sessions
1:00 pm - 3:00 pm	Technical Sessions
4:30 pm - 6:00 pm	Govt./Industry Workshops

Exhibit Hours

Dec. 3	10:00 am - 5:00 pm
Dec. 4	10:00 am - 5:00 pm
Dec. 5	10:00 am - 4:30 pm

Technology 2001 Exhibitors

Here are some of the more than 200 government R&D centers, universities, and high-tech firms exhibiting at Technology 2001:

Aerospace Lubricants Inc.
Aerospatiale
Agema Infrared Systems
Air Force Manufacturing Technology Directorate
Air Force Systems Command
Ambassador Marketing
American Ceramic Society
American Welding Society
Ames Laboratory
Ames Research Center
Ames Spatial Auditory Display Lab
AMPEX
Analytical Graphics
Armstrong Laboratory
Army Laboratory Command
Arthur D. Little Inc.
Assoc. of American Railroads/ US Department of Transportation
Astro-Med Inc.
Bend Research
BF Goodrich Aerospace Super-Temp
Biltech Inc.
Bit 3 Computer Corp.
Brookhaven National Laboratory
California Institute of Technology
Carnegie Mellon Robotics Institute
Center for Aerospace Information
Ceracon Inc.
Corning Inc.
COSMIC
Crystal River Engineering
Cybernet Systems
Datatape Inc.
Department of Energy
Design & Evaluation Inc.
Digiray Corp.
Earth Observation Satellite Company
Eastman Kodak Company
European Space Agency
Fabric Development Inc.
Fermi National Accelerator Lab
FLIR Systems Inc.
Goddard Space Flight Center
Government of Israel Trade Center
Hamilton Technologies
Hardigg Industries
Heimann Infrared Division/ Pyrometrics Corp.
Hemco Corp.
Hi-Techniques
Hitachi Denshi America Ltd.
HTS Inc.
Idaho National Engineering Lab
Industrial Materials Technology Inc.
Information Handling Services
Inframetrics Inc.
Integrated Engineering Software
Integrated Systems Inc.
Intel Corp.
Interfinance Corp.
IXYS Corp.
James Grunder & Assoc.
Jet Propulsion Laboratory
Johnson Space Center
JP Technologies Inc.
Keane Controls Corp.
Kennedy Space Center
Langley Research Center
Lawrence Livermore National Laboratory
Lewis Research Center
Los Alamos National Lab
Luxtron Corp., Accufiber Division
Magna Engineering Inc.
Mantech/NSI
Marshall Space Flight Center
Martin Marietta Energy Systems
Mathworks Inc.
McClellan Air Force Base
Mechanical Technology Inc.
Metalworking Technology Inc.
Metrum
Mikron Instrument Co.
Morgantown Energy Technology Center
NASA
NASA Regional Technology Transfer Centers
NASA Small Business Innovation Research
NASA Tech Briefs
National Center for Manufacturing Sciences
National Institute of Allergies & Infectious Diseases
National Institute of Standards and Technology
National Space Society
Naval Air Warfare Center
Naval Research Laboratory
NERAC Inc.
NIAC
Novespace
Numerical Algorithms Group
NYMA Inc.
Ohio Aerospace Institute
Olympus Corp.
Oracle Corp.
Pacific Northwest Laboratory
Pasha Publications
Patton & Patton Software
Phillips Laboratory
Pittsburgh Energy Technology Center
PMS Electro-Optics
Princeton Plasma Physics Laboratory
Proto Manufacturing Ltd.
Quantum Devices Ltd.
Raytheon Company
RGB Spectrum
RG Hansen & Associates
Ribbon Technology Corp.
Rockwell International
Rome Laboratory
Salco Circuits
Sandia National Laboratories
Simmonds Precision Aircraft Systems
SMTEK
Solar Energy Research Institute
Sorbilite Inc.
South Carolina Universities Research
Specialty Steel & Forge
Spiral Software
Stanford Research Institute
Stardent Computer Inc.
Statistical Sciences Inc.
Stennis Space Center
Stephens Analytical
Stereographics Corp.
Strategic Defense Initiative Organization
Sun Microsystems
Superior Products
Symbolics
TechLaw Group
Technical Insights Inc.
Technology Access Report
Technology Center of Silicon Valley
Technology Targeting Inc.
Technology Transfer Society
Tennessee Technology Foundation
Thin Film Technology Inc.
Tiodize Inc.
Ultramet
United Magnet Technologies
University of Dayton Research Institute
US Geological Survey
VA Medical Center, Rehab R&D Center
Vector Aeromotive Corp.
Virginia Center for Innovative Technology
Wisconsin Center for Space Automation and Robotics
Wolfram Research
Wright Laboratory

For information on having your organization exhibit at Technology 2001, call Justina Cardillo or Evelyn Mars at (800) 944-NASA. In NY, call (212) 490-3999.

See America's most advanced automobile — the Vector W8 TwinTurbo — in the Technology 2001 exhibit hall. Incorporating an array of aerospace technologies, this "supercar" goes from 0-60 mph in less than 3.8 seconds and reaches speeds of more than 200 mph.

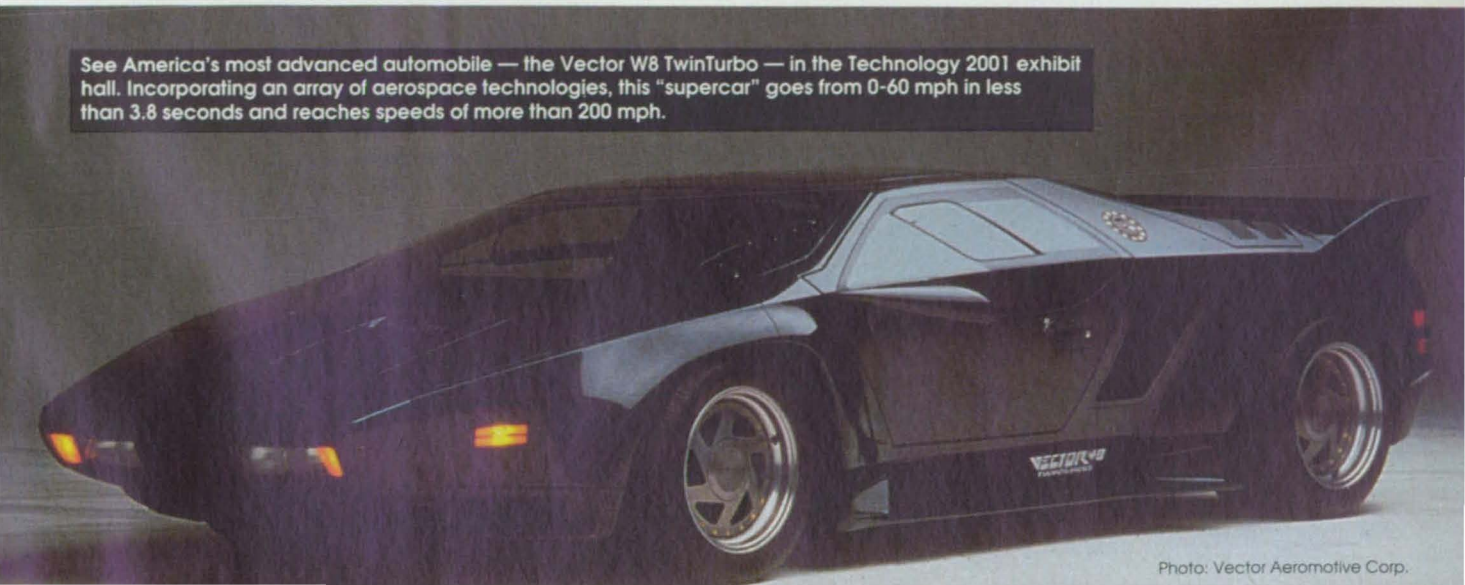

Photo: Vector Aeromotive Corp.

Technology 2001 Program

Tuesday, December 3

Plenary Session
9:00 am—10:30 am

(Speakers to be announced)

9:00: Welcome
9:15: Keynote Address
9:50: Technology 2001 Overview
10:15: Intelligent Processing Conference Overview

Concurrent Technical Sessions
1:00 pm—3:00 pm

Each presentation will last 30 minutes, including a question and answer period. Registrants may attend whole sessions (four presentations) or individual presentations from a number of different sessions. Meeting rooms are situated in close proximity for easy and quick movement during sessions. Room assignments will be listed in the final program distributed at the show.

(Session A1)

Advanced Manufacturing

Ceramic Susceptor for Induction Bonding of Metals, Ceramics, and Plastics

John D. Buckley, Senior Research Engineer, and Robert L. Fox, Electronics Technician, Langley Research Center

Langley researchers have developed a thin flexible carbon susceptor to join ceramics, plastics, metals, and combinations of these materials, using a unique induction heating process that dramatically reduces bonding times. The novel carbon susceptor allows application of heat directly and only to the bond line.

Applying NASA's Explosive Seam Welding

Laurence J. Bement, Senior Pyrotechnic Engineer, Langley Research Center

An explosive seam welding process created for aerospace use is finding a wide range of industrial applications. The process can be used to join aluminum and steel alloys, copper, brass, titanium, and other metals in thicknesses from 0.25 to 4.7 mm, and to remotely plug tubes.

Laser-Based Weld Joint Tracking System

Alan Looney, Welding Engineer, Marshall Space Flight Center

A laser-based system developed to control and monitor welding operations on space vehicles has been modified to provide a weld joint tracking system for industrial applications. The weld beam profiler features a precision laser-based vision sensor, automated two-axis machine motion, and an industrial PC controller. It eliminates weld repairs caused by joint tracking errors, reducing manufacturing costs.

Precision Joining Center

J.W. Powell, Joining Technology, EG&G Rocky Flats

Mr. Powell will describe a new center designed to provide a training ground for precision joining techniques. The center will transfer this advanced technology from the Department of Energy weapons complex and joining equipment manufacturers to US industries, through the training of technologists and engineers in such areas as process control, data acquisition, and joining.

(Session A2)

Biotechnology

Cooperative Research and Development Opportunities with the National Cancer Institute

Dr. Kathleen Sybert, Deputy Director, Office of Technology Development, National Cancer Institute

The National Cancer Institute's Office of Technology Development negotiates Cooperative Research and Development Agreements with university and industry investigators for the development of new products to diagnose and treat cancer and AIDS. Drug screening, preclinical testing, clinical trials, and AIDS program capabilities form the basis for this new technology transfer vehicle.

Technologies for the Marketplace from the Centers for Disease Control

Frances L. Reid-Sanden and R. Eric Greene, Technology Transfer Office, Centers for Disease Control

The Centers for Disease Control develops and transfers technologies designed to prevent and control disease and injury. Recent innovations include a vaccine against hepatitis A, a recombinant rabies vaccine, monoclonal antibodies for the detection of legionellae, a rapid method to diagnose human cysticercosis, and a variety of devices to ensure worker safety.

Enhancement of Biological Control Agents for Use Against Forest Insect Pests and Diseases

Dr. James M. Slavicek, Project Leader, US Forest Service Northeastern Forest Experiment Station

Dr. Slavicek will describe new biological control agents for use against forest pests such as the gypsy moth and diseases such as tree vascular fungal wilts.

Use of T7 Polymerase to Direct Expression of Outer Surface Protein A (OspA) from the Lyme Disease Spirochete, *Borrelia burgdorferi*

John J. Dunn, Senior Scientist, Brookhaven National Laboratory

Brookhaven researchers have cloned the ospA gene of *Borrelia burgdorferi*, the spirochete that causes Lyme disease. They are testing the resultant truncated protein for use as an immunogen in a vaccine against Lyme disease.

(Session A3)

Communications

Commercial Applications of ACTS Mobil Terminal Millimeter-Wave Antennas

Arthur C. Densmore, Antenna System Manager, and Rick A. Crist, Microwave Processor Subtask Manager, Jet Propulsion Laboratory

A JPL research team is developing low-profile, high-gain millimeter-wave antennas for future communication systems. Commercial opportunities include advanced land-mobile satellite communications, hybrid satellite/cellular systems, remote satellite news gathering, aeronautical and maritime satcom, and handheld personal satellite communications.

Antennas for Mobile Satellite Communications

John Huang, Jet Propulsion Laboratory

The NASA-sponsored Mobile Satellite Experiment program has generated several innovative microstrip antennas at L-band frequencies. Due to their thin profile, surface conformability, light weight, and low manufacturing cost, microstrip antennas are finding increasing applications in land-mobile satellite communications.

MMIC Linear-Phase and Digital Modulators for Space Communications Applications

Narayan R. Mysoor, Jet Propulsion Laboratory, and Fazal Ali, Pacific Monolithics

This presentation will review the design concepts, analyses, and development of monolithic microwave integrated circuit (MMIC) modulators for the next generation of space-borne communication systems. Commercial applications include phased arrays, satellite systems, and microwave systems that require continuous phase control in trimming multiple channels.

Phased-Array Antenna Beamforming Using an Optical Processor

Louis P. Anderson, Hughes Aircraft Company, and Richard Kunath, Lewis Research Center

Phased-array antennas are playing an increasingly important role in radar and communications applications, and will soon become the preferred way to achieve fixed spot, scanning spot, multiple spot, and other multi-functional beams for satellite communications. The presenters will discuss how a lightweight optical-processor-based beamformer can provide the required aperture excitations using a single lightweight network.

(Session A4)

Computer Graphics and Simulation

Global Positioning System Supported Pilot's Display

Marshall Scott, Systems Engineer, Kennedy Space Center

A new cockpit display for pilots of test aircraft uses the Global Positioning System to calculate aircraft position. This data is displayed graphically along with the runway, the desired flight path, and "fly-by" alignment needles.

Application of Technology Developed for Flight Simulation

Jeff I. Cleveland, Aerospace Technologist, Langley Research Center

Langley researchers are employing supercomputers for mathematical model computation to support real-time flight simulation. Mr. Cleveland will discuss commercial spinoff of these techniques in fields such as nuclear process control, power grid analysis, process monitoring, and chemical processing.

FAST: A Multi-Processed Environment for Visualization of Computational Fluid Dynamics

Gordon V. Bancroft, Fergus J. Merritt, Todd C. Plessel, Paul G. Kelaita, R. Kevin McCabe, and Al Globus, Research Scientists, Sterling Zero One Inc.

This presentation will focus on the Flow Analysis Software Toolkit (FAST), a software system for visualization and analysis of complex fluid flows. FAST is extensible and able to handle a wide range of problems. It can be adapted to new software and hardware configurations through modular structured programming methods, a graphics library standard, and common network communication protocols.

A Full-Parallax Holographic Display for Remote Operations

Helene P. Iavecchia, CSC/Analytics Inc.; Lloyd Huff, University of Dayton Research Institute; and Neville I. Marzwell, Jet Propulsion Laboratory

A near-real-time, full-parallax holographic display system developed for Jet Propulsion Laboratory could provide a 3D display for remote handling operations in hazardous environments on Earth and in Space.

(Session A5)

Electronics

Nonvolatile, High-Density, High-Speed, Magnet-Hall Effect Random Access Memory

Jiin-Chuan Wu, Romney R. Katti, and Henry L. Stadler, Flight Command and Data Management Systems, Jet Propulsion Laboratory

A radiation-hard, nonvolatile random access memory cell (MHRAM) with a density of 1 Mbit/cm^2 and an access time of less than 100 nsec is being developed using a magnet-Hall effect element. Such a memory will have a very competitive performance/price ratio to replace current commercial nonvolatile memory technologies, including ROM, EPROM, EEPROM, and Flash EEPROM, and will be competitive with static RAM for many applications.

Analog VLSI Neural Network Integrated Circuits

Francis Kub, Head, Microelectronic Device Physics Section, Naval Research Laboratory

Using a standard CMOS foundry process, Navy researchers have fabricated analog VLSI vector-matrix multiplier integrated circuit chips that perform vector-matrix multiplication operations at speeds up to 3 billion multiplications per second. Such high-speed operations are required for artificial neural networks and many signal processing applications, including image processing.

Monolithic Microwave Integrated Circuit Water Vapor Radiometer

L.M. Sukamto, Spacecraft Telecommunications Equipment Section, Jet Propulsion Laboratory

Mr. Sukamto will discuss efforts to design and fabricate a 31.4 GHz monolithic microwave integrated circuit (MMIC) radiometer as one channel of a thermally-stable water vapor radiometer (WVR). With improved thermal stability and signal accuracy, the WVR will have far-ranging commercial applications. It can be used, for example, in weather pattern prediction, calibration of polar-orbiting and geostationary satellites, and monitoring of aircraft icing conditions.

A Noncontacting Waveguide Backshort for Millimeter and Submillimeter Wave Frequencies

William R. McGrath, Technical Group Leader, Jet Propulsion Laboratory

A new backshort design employs a metallic bar with rectangular or circular holes to provide a periodic variation of guide impedance. The size, shape, and spacing of the holes can be adjusted to provide a large reflection of rf power over a useful frequency bandwidth. Mechanically rugged and easy to fabricate for frequencies up to 1000 GHz, the backshort offers applications in radar and communication systems, microwave test instruments, and remote-sensing radiometers, and will help extend waveguide technology into the submillimeter wave band.

(Session A6)

Materials Science

Novel Applications for TAZ-8A

William J. Waters, Sverdrup Technology Inc., and Stephen M. Riddlebaugh, Lewis Research Center

Alloy research for jet engine applications has produced a commercially promising nickel-based alloy called TAZ-8A. The alloy's unique combination of properties includes high temperature strength, oxidation resistance, abrasion resistance, and exceptional thermal shock resistance. Using a plasma vapor deposition technique, TAZ-8A can be applied as a coating with high reflectivity and extreme hardness.

Test Methods for Determining the Suitability of Metal Alloys for Use in Oxygen-Enriched Environments

Joel Stoltzfus, Projects Manager, White Sands Test Facility

Mr. Stoltzfus will describe test methods developed by NASA to study the ignition and combustion of metal alloys, including high- and low-speed particle impact tests, frictional heating and coefficient-of-friction tests, and the promoted combustion test. Test data and the resultant rankings of metal alloys will be discussed, along with licensing opportunities.

A Major Advance in Powder Metallurgy

B.E. Williams, J.J. Stiglich, R.B. Kaplan, and R.H. Tuffias, Ultramet

Under SBIR funding from the Army, Ultramet has developed a process that promises to significantly increase the mechanical properties of powder metallurgy (PM) parts. Conventional PM fabrication processes typically result in nonuniform distribution of the matrix, flaw generation due to particle-particle contact, and grain growth caused by high-temperature, long-duration compaction processes. In Ultramet's process, each particle is coated with

the matrix material, and compaction is performed by solid-state processing, improving the part's homogeneity.

Permanent Magnet Design Methodology
Dr. Herbert A. Leupold, Research Physicist, US Army Electronics Technology and Devices Laboratory

The high remanences and coercivities of rare earth permanent magnets have made possible magnet structures of unusual form and performance, including permanent magnet solenoids, cylindrical transverse field sources, and high-field permanent magnet field sources. Dr. Leupold will describe military and commercial applications such as MR imagers, traveling wave tubes, gyrotrons, free electron lasers, Faraday rotators, and ultraviolet/x-ray telescopes.

Concurrent Government-Industry Workshops 4:30 pm—6:00 pm

(Presenters to be announced)
In these highly-interactive sessions, federal agencies will brief attendees on their present and planned R&D initiatives and technology transfer mechanisms, spotlighting opportunities for industry to work with the government to develop and commercialize technology. Cooperative Research and Development Agreements, Small Business Innovation Research, and patent licensing will be discussed. The objective of these workshops is to begin a dialog that will lead to increased use of federally-sponsored technologies by industry, and better utilization of private sector resources by the government. Agencies holding workshops during this time period will include:

- Department of Defense
- Department of Energy
- Department of Health and Human Services
- Environmental Protection Agency

Wednesday, December 4

Concurrent Technical Sessions 8:30 am—10:30 am

(Session B1)
Advanced Manufacturing

Concentrating Solar Systems: Manufacturing with the Sun
Lawrence M. Murphy, Division Director, Bimleshwar P. Gupta, Program Manager, and Steven G. Hauser, Industry Liaison, Solar Energy Research Institute

Recent advances in concentrating solar systems have produced solar flux densities in excess of 20,000 suns, creating unique process conditions of very high temperatures and heating rates. These conditions enable applications in manufacturing, materials processing, surface engineering, and toxic waste destruction.

Ultra-Precision Processes for Optics Manufacturing
William R. Martin, Associate Director, Engineering Technology Division, Oak Ridge National Laboratory

The Optics MODIL (Manufacturing Operations Development and Integration Laboratory) is developing advanced manufacturing technologies for fabrication of ultra-precision optical components, aiming for a ten-fold improvement in precision and a shortening of the schedule lead time. Discussion will focus on diamond single point turning, ductile grinding, ion milling, and in/on process metrology.

Integrated Automation for Manufacturing of Electronic Assemblies
T. Joseph Sampite, CIM Program Manager, Naval Ocean Systems Center

Mr. Sampite will describe how a standardized file transfer format developed with the National Institute of Standards and Technology will be used to create generic, open architecture computer-aided engineering tools for the automatic exchange of data between design and manufacturing.

Air Force Manufacturing Technology (MANTECH) Technology Transfer
Tracy J. Houpt, MTX Program Manager, and Margaret M. Ridgely, Technology Transfer Center Director, Wright Patterson Air Force Base

This presentation will illustrate the techniques and concepts employed in Air Force MANTECH's new comprehensive, proactive technology transfer program, using as an example the successful transfer of transmit/receive modules to industry.

(Session B2)
Electronics

Gallium Arsenide Quantum-Well-Based Far Infrared Array Imaging Radiometer
Kathrine A. Forrest and Murzy D. Jhabvala, Electronics Engineers, Goddard Space Flight Center

A new imaging radiometer developed for the thermal infrared (8 to 12 microns) employs a staring 128 x 128 GaAs quantum well detector array for stability, uniformity, high yield, and radiation-hardness. It is suited for thermal imaging in forestry, electronics processing, and medicine. Potential applications include aerial detection of small forest fires and location of hot spots in integrated circuits.

A Video Event Trigger for High-Frame-Rate, High-Resolution Video Technology
Glenn L. Williams, Electrical Engineer, Lewis Research Center

Mr. Williams will describe a highly-parallel digital state machine that generates a trigger signal at the onset of a video event. Random access memory storage coupled with fuzzy comparator logic devices permit monitoring a video stream for long- or short-term changes caused by spatial translation, dilation, or color change. Pretrigger and post-trigger storage techniques allow researchers to archive only significant images, alleviating costly data storage problems.

Camera Orientation of Pan, Tilt, and Zoom with No Moving Parts
Dr. H. Lee Martin, President, and Steven D. Zimmermann, Design Engineer, TeleRobotics International Inc.

Under contract to NASA Langley, TeleRobotics has developed a remote viewing system that provides pan, tilt, zoom, and rotational capabilities with no moving parts. The system features a fisheye lens for complete hemispherical field-of-view imaging and high-speed image transformation to correct peripheral distortion. Applications include remote viewing, inspection, and surveillance.

Fiber Optic TV Camera Direct
John Edward Kassak, Electronics Engineer, Kennedy Space Center

The Kennedy Center is developing a multiple color camera system for installations where video, synchronization, control camera data, and status data are transmitted via a single fiber cable at distances exceeding five miles. Expected benefits include improved video performance, immunity from EMI and RFI, and more broadcast flexibility.

(Session B3)
Environmental Technology

Waste Management Technology Development and Demonstration Programs
Paul D. Kalb, Research Engineer, Brookhaven National Laboratory

Brookhaven researchers have developed two new thermoplastic processes for the disposal of hazardous wastes: polyethylene encapsulation of nitrate salt wastes and modified sulfur cement encapsulation of incinerator fly ash wastes. Both systems provide significant improvements over conventional solidification techniques and result in durable waste forms that meet regulatory criteria.

Regulated Bioluminescence as a Tool for Bioremediation Process Monitoring and Control of Bacterial Cultures
Robert S. Burlage, Environmental Sciences Division, Oak Ridge National Laboratory; Armin Heitzer and Philip Digrazia, Center for Environmental Biotechnology, University of Tennessee

A new technique for monitoring biodegradation in toxic waste sites employs bioluminescence in a recombinant bacterial strain to detect contaminant levels. The process is rapid, often completed in minutes, and is sensitive in the part-per-billion range.

Fiber-Optic-Based Biosensor
Joel M. Schnur, Head, Molecular Science and Engineering Center, Naval Research Laboratory

Mr. Schnur will illustrate a new fiber-optic-based biosensor for environmental monitoring, pollution control, and clinical diagnostics. The device integrates a novel array of components, long fused silica fibers, and proteins for detection.

Ambient Temperature CO Oxidation Catalysts
Billy T. Upchurch, Senior Research Scientist, Langley Research Center

Langley researchers have produced ambient temperature oxidation catalysts for the recombination of CO and CO_2 dissociation products formed during CO_2 laser operation. The catalysts allow continuous operation of CO_2 lasers in a closed-cycle mode, and offer applications in other closed environments where the removal or control of CO is required, such as in catalytic converters for control of auto emissions.

(Session B4)

Materials Science

High-Temperature Adhesives
Terry L. St. Clair, Head, Polymeric Materials Branch, Langley Research Center

LARC-TPI, a high-temperature linear polymer adhesive developed to bond titanium, offers application as a hot-melt adhesive. Mr. St. Clair will describe the chemical structure and physio-mechanical properties of LARC-TPI and other important new polyimides with commercial potential.

Fluorinated Epoxy Resins with High Glass Transition Temperatures
James R. Griffith, Research Chemist, Naval Research Laboratory

The Navy has developed a new class of easily-processed liquid resins with low dielectric constants and high glass transition temperatures. These materials are useful for the manufacture of composite electronic boards.

Polyimides Containing Pendent Siloxane Groups
John W. Connell, Polymer Scientist, Langley Research Center

Incorporation of siloxane units into the backbone of aromatic polyimides imparts enhanced solubility, lower moisture adsorption, lower dielectric constant, improved toughness, and protection against atomic oxygen erosion. Mr. Connell will describe the physical and mechanical properties of these materials, as well as potential electronics and aerospace applications.

Corrosion-Protective Coatings from Electrically-Conducting Polymers
Karen Thompson, Kennedy Space Center; Brian Benicewicz and Debra Wrobleski, Los Alamos National Laboratory

Researchers are investigating the use of processible conductive organic polymers as corrosion-protective coatings on metal surfaces. Recent tests in saline and acidic oxidizing environments have demonstrated greatly improved corrosion resistance of mild steel with these coatings as compared to steel coated solely with epoxy.

(Session B5)

Medical Advances: Computers in Medicine

Computation of Incompressible Viscous Flows through Artificial Heart Devices
Stuart Rogers and Dochan Kwak, Research Scientists, Ames Research Center

Ames researchers are applying computational fluid dynamics (CFD) techniques to simulate the blood flow through artificial hearts. Computer modeling will help pinpoint regions subject to clotting and lead to safer, more durable mechanical hearts and valves.

Computer Interfaces for the Visually Impaired
Gerry Higgins, Computer Systems Engineer, Marshall Space Flight Center

Mr. Higgins will address current research efforts to provide computer technology for people with vision-related handicaps. One such effort, the Mercator Project, looks to create a prototype system for audible access to graphics-based interfaces.

Extended Attention Span Training System
Dr. Alan Pope, Leader, Human Engineering Methods Group, Langley Research Center

A biocybernetic system developed to assess the degree to which automated flight management systems maintain pilot engagement is being adapted for treatment of youngsters with attention disorders. The Extended Attention Span Training (EAST) system increases the difficulty of a video game as the player's brain waves indicate attention is waning. The player can only succeed at the game by maintaining an adequate attention level.

Man/Machine Interaction Dynamics and Performance Analysis Capability
Harold P. Frisch, Head, Robotic Applied Research, Goddard Space Flight Center

As part of its flight telerobotics program, NASA is developing the ability to study the consequences of machine design alternatives as they relate to machine and machine operator performance. This capability will have far-reaching medical applications, such as enabling orthopedic surgeons to study the consequences of surgical options from the perspective of post-operative human performance predictions.

(Session B6)

Software Engineering

Hybrid Automated Reliability Predictor Integrated Workstation (HiREL)
Salvatore J. Bavuso, Aerospace Technologist, Langley Research Center

The HiREL system marks a major step toward producing a totally integrated CAD workstation design capability. HiREL uses a graphical input description language to increase productivity and reduce error. It enables reliability engineers to quickly analyze huge amounts of reliability/availability data to observe trends due to exploratory design changes.

Using Ada and the Rapid Development Lifecycle
Lloyd DeForrest, Technical Group Supervisor, Jet Propulsion Laboratory

Under contract to the US Army, JPL is developing a multifaceted computerized command center using an accelerated software development approach called the Rapid Development Lifecycle. Through the use of Ada and the X-Window/Motif Graphical User Interface, software developed under this program can be reused in similar projects requiring non-computer-literate users with little or no training to operate advanced command center tools and applications.

Advances in Knowledge-Based Software Engineering
Walt Truszkowski, Head, Automation Technology Section, Goddard Space Flight Center

The Knowledge-Based Software Engineering Environment (KBSEE) is designed to demonstrate that a rigorous and comprehensive software

reuse methodology can enable more efficient utilization of resources in the development of large-scale software systems. Designed for use by both government and industry, KBSEE could aid in improving the reliability of future software systems.

Reducing the Complexity of Software Development through Object-Oriented Design
Mary Pat Schuler, Aerospace Technologist, Langley Research Center

Ms. Schuler will illustrate how Object-Oriented Design (OOD), coupled with formalized documentation and tailored object diagramming techniques, can simplify the software design process. The OOD methodology uses a hierarchical decomposition approach in which parent objects are decomposed into layers of lower-level child objects, with the relationships between design layers represented pictorially. This approach makes the resulting code more portable, reusable, and maintainable.

Concurrent Technical Sessions 1:00 pm—3:00 pm

(Session C1)

Data and Information Management

Techniques for Efficient Data Storage, Access, and Transfer
Robert F. Rice, Jet Propulsion Laboratory, and Warner Miller, Goddard Space Flight Center

Advanced techniques for efficient data representation have been placed in practical hardware and software form though the joint effort of three NASA centers. The techniques, which involve the use of high-speed coding and decoding modules as well as machine-transferable software routines, adapt to local statistical variations to continually provide optimum code efficiency when representing data without error.

A Vector-Product Information Retrieval System Adapted to Heterogeneous, Distributed Computing Environments
Dr. Mark E. Rorvig, Library Scientist, Johnson Space Center

The Automated Online Library Management System (AutoLib) provides a ranked list of the most likely relevant objects in collections, in response to a natural language query. AutoLib is constructed with standards and tools such as UNIX and X-Windows, which permit its use in organizations that have many different hosts, workstations, and platforms. Applications include information-intensive corporate management environments, such as finance, manufacturing, and biotechnology.

AutoClass: An Automatic Classification System
Peter Cheeseman, Research Scientist, Ames Research Center

A useful tool for exploratory data analysis, AutoClass enumerates and describes the natural classes in a data set. The program automatically determines the optimal number of classes.

Silvabase: A Flexible Data File Management System
Steven J. Lambing, Marshall Space Flight Center, and Steven T. Harris, Boeing Computer Support Services

Developed for mission planning at the Marshall Center, Silvabase enables efficient forward and backward sequential reads, random searches, and appends to large amounts of data. The system, designed to run on VAX/VMS computers, has unique features applicable to management of data involving time histories and intervals such as in operations research.

(Session C2)

Electro-Optics

Nonlinear Optical Polymers for Electro-Optic Signal Processing
Geoffrey A. Lindsay, Polymer Science Branch Head, Naval Weapons Center

Mr. Lindsay will discuss several new classes of nonlinear optical polymers for use in optical signal processing (photonics). These materials offer large electro-optics figures of merit, high temperature performance, ease of processing into films and fibers, ruggedness, and low cost. They can be applied in electro-optic switches, optical frequency doublers, sensors, spatial light modulators, and optical data storage systems.

High-Resolution Optical Data Storage on Polymers
C.M. Roland, Supervisory Chemist, Naval Research Laboratory

A new thermal method for lithography on amorphous polymer films yields remarkably high resolution images with excellent edge acuity. Images imparted to the films can be made electrically conductive via a single-step process, without using extraneous reagents.

Laser Discrimination by Stimulated Emission of a Phosphor
Dr. V.K. Mathur, Research Physicist, Naval Surface Warfare Center

Dr. Mathur will describe a new method for discriminating near infrared and far infrared laser light sources, based on the use of a magnesium sulfide phosphor which is thermally/optically stimulated to generate a color correlatable to the incident laser radiation. The technology offers potential for discrimination between even smaller bandwidths within the infrared spectrum—a possible aid to communication or wavemixing devices that need to rapidly identify and process optical signals.

Pulsed Laser Prelasing Detection Circuit
George Eugene Lockard, Engineering Technician, Langley Research Center

Langley researchers have developed a circuit to detect prelasing—the premature leakage of energy from a laser rod—in pulsed laser systems. The circuit, which is small, economical, and easily incorporated into virtually any pulsed laser system, shuts off the laser before the prelasing energy can cause costly optical damage.

(Session C3)

Life Sciences

Application of CELSS Technology to Controlled Environment Agriculture
Dr. Maynard E Bates, Bionetics Corporation, and Dr. David L. Bubenheim, Ames Research Center

Controlled Ecological Life Support Systems (CELSS) expand the concept of Controlled Environment Agriculture (CEA)—the use of environment manipulation for the commercial production of organisms—to create miniature ecosystems in which food, oxygen, and water in closed habitats are provided by regeneration of waste streams through systems containing microorganisms, plants, and animals. The development of CELSS will provide information needed to improve the efficiency, reliability, and cost-effectiveness of CEA, while reducing its environmental impact to negligible levels.

Advanced Forms of Spectrometry for Space and Commercial Application
Dr. Kenneth J. Schlager, Chief Technical Officer, Biotronics Technologies Inc.

Biotronics has discovered wide commercial application for two spectrometric technologies developed under the Kennedy Space Center's sponsorship. Ultraviolet absorption spectrometry, originally investigated for on-line measurement of hydroponic plant nutrient solutions, is finding utility in a new line of ultraviolet process analyzers for the water treatment market. A second technology, liquid atomic emission spectrometry, holds even greater commercial promise, representing the first application of atomic emission to direct on-line measurements of liquids.

Ion-Selective Electrode for Ionic Calcium Measurements
John W. Hines and Sara Arnaud, Research Scientists, Ames Research Center

NASA has developed a coated wire ion-selective electrode that noninvasively

measures ionic calcium. It can be used to monitor bone calcium changes during extended exposure to microgravity or during prolonged hospital or fracture immobilization, and to conduct osteoporosis research.

A 99% Purity Molecular Sieve Oxygen Generator
Major George W. Miller, Research Chemical Engineer, Air Force Systems Command

A molecular sieve oxygen generator employing a new pressure swing adsorption process produces oxygen concentrations of up to 99.7% directly from air, exceeding the present oxygen purity limitations of 93-95%. The device may find use in aircraft and medical breathing systems, and industrial air separation systems.

(Session C4)

Materials Science

Advanced Composite Materials and Processes
Robert M. Baucom, Group Leader, Composite Materials, Langley Research Center

Mr. Baucom will report on techniques for combining high-performance graphite fibers and resin matrix systems into composite prepregs, innovative tooling concepts, and fabrication procedures for complex structures. The plastics and aerospace industries could benefit greatly by adopting these materials and processing procedures.

RTM: Cost-Effective Processing of Composite Structures
Greg Hasko and H. Benson Dexter, Materials Research Engineers, Langley Research Center

Resin transfer molding (RTM), a method of making high-strength, lightweight composite structures, is used extensively in the automotive, recreation, and aerospace industries. The presenters will compare the material requirements of various industries, methods of orienting and distributing fibers, mold configurations, and processing and material parameters such as resin viscosity, preform compaction, and permeability.

A Low-Cost Method of Testing Compression-After-Impact Strength of Composite Laminates
Alan Nettles, Marshall Space Flight Center

Marshall researchers have developed a new method to test the compression strength of composite laminate specimens as thin as .04 inches and up to 3 inches wide. This method is easier and less costly than the current compression-after-impact standard, and yields more meaningful results.

Resonant Acoustic Determination of Complex Elastic Moduli
Steven L. Garrett, Professor of Physics, and David A. Brown, Electronics Engineer, Naval Postgraduate School

The presenters will describe a new technique for measuring and tracking the complex shear and Young's moduli of nonmagnetic samples using the resonance frequency of an unconstrained bar sample. The same inexpensive electrodynamic transducers are used to excite and detect the sample's longitudinal, flexural, and torsional resonances. Sample data for composites, metals, plastics, and viscoelastic materials will be presented.

(Session C5)

Robotics

A Unique Cable Robot for Space and Earth
James Kerley, Design Engineer, Goddard Space Flight Center

A novel cable robot bends like a worm, moving up and down, back and forth, and even upside down. With magnets on its feet, the robot can climb or adhere to tall structures. It can be used to clean or paint towers, tanks, bridges, and ships, and, with an attached video camera, to inspect structures for damage or rust.

A Lightweight, High-Strength Dexterous Manipulator Arm
Neville I. Marzwell, Jet Propulsion Laboratory; Bruce M. Schena and Steve M. Cohan, Odetics Inc.

The presenters will describe the design and features of a lightweight, high-strength, modular manipulator arm developed for space and commercial applications. Fully operational in 1 g, the arm has seven degrees of freedom, a reach of 55 inches, and can lift 50 pounds. Bilateral teleoperator control can be added to the current robotically operated system.

Real-Time, Interactive Simulator System for Telepresence
Neville I. Marzwell, Jet Propulsion Laboratory; A.H. Chiu, P.G. Gottschalk, F.S. Schebor, and J.L. Turney, KMS Fusion Inc.

The Global-Local Environment Telerobotics Simulator (GLETS) immerses an operator in a real-time, interactive, visually-updated simulation of the remote telerobotic site. Stereo graphics are shown on a computer screen and fused together by the operator's special glasses to form stereoscopic views of the simulated world. The operator, interacting with the GLETS through voice and gesture commands, can form a gestalt of the virtual "local site" that matches his/her normal interactions with the real remote site.

A Hazard Control System for Robot Manipulators
Ruth Chaing Carter, FTS System Safety Manager, Goddard Space Flight Center

Ms. Carter will review system safety management and engineering techniques developed for telerobotic operations in space, focusing on a precise hazard control system for test flight of NASA's Flight Telerobotic Servicer. The same software monitoring and control approach could ensure the safe operation of a slave manipulator under teleoperated or autonomous control in undersea, nuclear, or manufacturing applications.

(Session C6)

Test and Measurement

Knowledge-Based Autonomous Test Engineer (KATE)
Dr. Carrie Belton and Barbara Brown, Computer Engineers, Kennedy Space Center

Developed for ground launch operations at the Kennedy Center, KATE employs concepts of sensor-based and model-driven monitoring and fault-location, and performs control and redundancy management of process control systems. KATE is designed as a generic, model-based expert system shell for autonomous control, monitoring, fault recognition, and diagnostics in the electrical, mechanical, and fluid system domains.

Advanced Computed Tomography Inspection System (ACTIS)
Lisa H. Hediger, Materials Engineer, Marshall Space Flight Center

ACTIS, developed at the Marshall Center to support its solid propulsion test programs, is being applied to inspection problems in the aerospace, lumber, automotive, and nuclear waste disposal industries. Ms. Hediger will discuss the unique capabilities of ACTIS and present a broad overview of computed tomography technology.

High-Resolution Ultrasonic Spectroscopy System for Nondestructive Evaluation
Dr. C.H. Chen, Information Research Laboratory Inc.

Under SBIR funding from the Army, IRL researchers are developing a high-resolution ultrasonic inspection system supported by modern signal processing, pattern recognition, and neural network technologies. This presentation will review the details of the system and its software package.

Force Limited Vibration Testing
Terry D. Scharton, Jet Propulsion Laboratory

An improved method of controlling vibration tests used to verify equipment design and manufacturing workman-

ship closely simulates field conditions. Offering commercial application throughout the aerospace, electronics, and automotive industries, the new test method eliminates costly failures associated with overtesting in the laboratory.

Concurrent Government-Industry Workshops
4:30 pm—6:00 pm

(Presenters to be announced)
Agencies holding workshops during this period will include:

- Department of Energy
- Department of Veterans Affairs
- Environmental Protection Agency
- National Aeronautics and Space Administration

Thursday, December 5

Concurrent Technical Sessions
8:30 am—10:30 am

(Session D1)

Advanced Manufacturing

Development of a Rotary Joint Fluid Coupling for Space Station Freedom
John A. Costulis, Technical Project Engineer, Langley Research Center

Langley researchers have developed and tested a 360-degree rotary joint fluid coupling for the Freedom station's thermal control system. The mechanism can be applied commercially to transfer fluid across rotating interfaces, such as in gun turrets, coal slurries, and farming machinery.

Spline Screw Comprehensive Fastening Strategy
John M. Vranish, Electronics Engineer, Goddard Space Flight Center

A fastener developed for assembly, maintenance, and equipment replacement operations in space also has down-to-Earth manufacturing applications. Use of the "spline screw" fastener in prime subassemblies would enable machines to disconnect and replace parts with ease, reducing product life cycle costs and enhancing the quality, timeliness, and consistency of repairs and upgrades.

Commercial Application of an Innovative Nut Design
Jay Wright, Materials Research Engineer, Johnson Space Center

A nut developed for space station use allows a fastener to be inserted or removed from either side by simply sliding the fastener in or out of the nut. Detentes on either face of the nut ensure positive engagement of the threads. The nut has applications wherever a fastener needs to be taken on and off quickly or used on a threaded part which could become so damaged that a conventional nut could not be removed.

Inflatable Traversing Probe Seal
Paul A. Trimarchi, Mechanical Engineer, Lewis Research Center

Mr. Trimarchi will describe an inflatable seal that acts as a pressure-tight zipper to provide traversing capability for instrumentation rakes and probes. The seal can replace sliding face-plate/O-ring systems in applications where lengthwise space is limited.

(Session D2)

Artificial Intelligence

CLIPS: An Expert System Building Tool
Gary Riley, Computer Engineer, Software Technology Branch, Johnson Space Center

The C Language Integrated Production System (CLIPS) provides a complete environment for the development and delivery of rule- and/or object-based expert systems. CLIPS offers a low-cost option for developing and deploying expert system applications across a wide range of hardware platforms.

Fuzzy Logic Applications to Expert Systems and Control
Dr. Robert N. Lea, Aerospace Engineer, Johnson Space Center

Commercial use of fuzzy technology in Japan and China indicate that it should be exploited by government and private industry to save energy and reduce human involvement in industrial processes. Johnson Center researchers have applied fuzzy logic in guidance control systems for space vehicles, control of data processing during rendezvous navigation, collision avoidance algorithms, and camera tracking controllers. The technology may also find use in diagnostic systems, control of robotic arms, pattern recognition, and image processing.

Neural Network Technologies
James A. Villarreal, Computer Engineer, Johnson Space Center

Mr. Villarreal will describe the Neural Execution and Training System (NETS), a software tool designed to facilitate and expedite the use of neural network technology in industry, government, and academia. Neural networks have been successfully applied to modeling and data fusion problems, robotics, structural design, speech synthesis, financial forecasting, spectrographic analysis, and many other areas. This presentation will highlight various commercial projects under development with NETS.

From Biological Neural Networks to Thinking Machines
Dr. Muriel D. Ross, Research Scientist, Ames Research Center

Dr. Ross is studying the three-dimensional organization of a simple biological neural network found in inner ear organs of balance to uncover basic principles of neural organization and function. This effort will result in new applications of biological attributes to artificial systems, and could lead to the development of highly-intelligent parallel-processing computers.

(Session D3)

Biotechnology

The Microassay on a Card—A Rugged, Portable Immunoassay
Dr. David Kidwell, Research Scientist, Naval Research Laboratory

The Microassay on a Card (MAC), a portable, handheld immunoassay, can test for a wide variety of substances in the environment. Intended for use as an on-site screen for drugs of abuse in urine or saliva, the MAC may also be applied to test for intoxication, to identify seized materials, and to test for environmental pollutants.

Flow Immunosensor for Drug Detection
Joel M. Schnur, Head, Molecular Science and Engineering Center, Naval Research Laboratory

Dr. Schnur will describe an antibody-based sensor designed to detect drugs of abuse. The biosensor is faster, less expensive, and as sensitive as any current method for cocaine detection. It can be operated outside the laboratory by personnel with no scientific training. Opportunities exist for Cooperative Research and Development Agreements.

Nucleic Acid Probes in Diagnostic Medicine
Phillip A. O'Berry, National Technology Transfer Coordinator for Animal Science, US Department of Agriculture

Mr. O'Berry will discuss the application of nucleic acid probe technology to the diagnosis of disease in humans and animals, and will present examples of commercially-promising probes.

The Rotating Spectrometer: New Biotechnology for Cell Separations
David A. Noever, Universities Space Research Association, and Helen C. Matsos, Marshall Space Flight Center

A new rotating spectrometer, able to separate previously inseparable cell cultures, is intended for use in pharmacological studies requiring fractional splitting of heterogeneous cell cultures based on cell morphology and swimming behavior. Unlike standard separation and concentrating techniques such as filtration or centrifuga-

tion, the instrument can separate motile from immotile fractions.

(Session D4)

Electronics

Method for Producing High-Quality Oxide Films on Surfaces

Mark W. Ruckman, Associate Physicist, Brookhaven National Laboratory

Mr. Ruckman will describe a new method for the reactive deposition of metal oxide and other inorganic compound thin films for use in microelectronic devices fabricated on compound semiconductors and high-temperature superconducting oxides. The technology can be integrated with ion, electron, or photon beam methods used to accelerate or selectively promote deposition and etching.

Advanced Silicon on Insulator Technology

Francis J. Kub, Senior Research Engineer, and David J. Godbey, Research Chemist, Naval Research Laboratory

Navy researchers have developed bonding, thinning, and selective etching techniques for producing ultra-thin silicon on insulator materials. These techniques can be used to fabricate silicon membranes, balometers, and other devices requiring free-standing thin-film silicon. Other applications include high-voltage/high-temperature power devices, backside-illuminated thinned CCD imagers, and x-ray masks.

High-Temperature Superconducting Stripline Filter

J.J. Bautista, Technical Group Supervisor, Jet Propulsion Laboratory

Mr. Bautista will describe the fabrication of a five-pole interdigital stripline filter made of the 93K superconductor $Y_1Ba_2Cu_3O_y$ coated on a silver substrate. The filter features a center frequency of 8.5 GHz and an extremely high rejection ratio of 80 dB.

An Adjustable rf Tuning Element for Microwave, Millimeter Wave, and Submillimeter Wave Circuits

William R. McGrath, Technical Group Leader, Jet Propulsion Laboratory; Victor Lubecke and David B. Rutledge, Dept. of Electrical Engineering, California Institute of Technology

The presenters have developed an adjustable rf tuning element consisting of a series of thin plates that can slide in unison along a coplanar strip transmission line to allow active tuning. The structure can be fabricated for frequencies as high as 1000 GHz using existing micromachining techniques. By easing constraints on circuit design, it will aid in extending microwave integrated circuit technology into the high millimeter wave and submillimeter wave bands.

(Session D5)

Materials Science

Passive Chlorophyll Detector

Leonard A. Haslim, Research Scientist, Ames Research Center

Using a low-cost, uniquely-dyed optical filter plastic sheet, the Passive Chlorophyll Detector enhances the visual discrimination of vegetation and trees in varying states of health. The invention's far-reaching applications include enabling farmers to identify and nurse or replant unhealthy sections of their fields to achieve higher crop yields, and serving as an early warning device for environmental scientists monitoring the health of forests and wetlands exposed to acid rain or contaminated groundwater.

Commercial Application of Thermal Protection System Technology

Gordon L. Dyer, Technology Transfer Officer, Martin Marietta Manned Space Systems

Thermal protection system materials and processes developed for the space shuttle's external tank have been reapplied in a new type of children's lunch box—a microwavable urethane foam insulation container that keeps a prepackaged meal warm for four to five hours. Two major food manufacturers are currently considering licensing the high-tech foam container.

Oxynitride Glass Fibers

Donald R. Messier, Research Ceramic Engineer, Materials Technology Laboratory, US Army Laboratory Command

Oxynitride glasses offer exciting opportunities for making high-modulus, high-strength glass fibers. Mr. Messier will describe processes for fabricating oxynitride glasses and fibers in compositions similar to commercial oxide glasses, but with significantly enhanced properties.

Commercial Applications of Advanced Photovoltaic Technologies

R.D. McConnell, Technology Transfer Manager, Solar Energy Research Institute

Mr. McConnell will describe research into high-tech photovoltaic materials including III-V, II-VI, amorphous silicon, and crystalline silicon, and will highlight possible spinoff applications such as optoelectronics and space power systems.

(Session D6)

Software Engineering

Software Reengineering

Ernest M. Fridge, Deputy Chief, Software Technology Branch, Johnson Space Center

During space shuttle development, Johnson Center engineers created a set of tools to develop and maintain FORTRAN and C code. This tool set forms the basis for an integrated environment to reengineer existing code into modern software engineering structures which are easier and less costly to maintain and which allow straightforward translation into other target languages.

COSTMODL: An Automated Software Development Cost Estimation Tool

George B. Roush, Software Engineer, Johnson Space Center

One of the most widely used software cost estimation tools, COSTMODL can help reduce the risk of cost overruns and failed projects. COSTMODL has an intuitive user interface and extensive online help system, and can be customized to a particular user environment. It can be used for in-house cost management, cost analysis consulting, or for research.

Increasing Productivity through Total Reuse Management

Mary Pat Schuler, Aerospace Technologist, Langley Research Center

NASA Langley is promoting total reuse management (TRM) as a way to lower software development costs, reduce risk, and increase code reliability. Ms. Schuler will describe methods used to adopt TRM, and will discuss the reuse of products from all phases of the software life cycle.

How Hypermedia Can Increase the Productivity of Software Development Teams

L. Stephen Coles, Group Chief Technologist, Institutional Data Systems, Jet Propulsion Laboratory

Mr. Coles will describe how the productivity of software developers can be dramatically improved through the use of hypermedia, the seamless integration of disparate data structures—including text, graphics, animation, voice, and full-motion video—in a graphical user interface. The presentation will cover basic machine architecture, special-purpose video boards, video equipment, optical memory, software for animation, voice I/O, and networking and integration issues.

Concurrent Technical Sessions
1:00 pm—3:00 pm

(Session E1)

Advanced Manufacturing

Intelligent Robotic System with Dual-Arm Dexterous Coordination and Real-Time Vision

Neville I. Marzwell, Jet Propulsion Laboratory, and Alexander Chen, Scientific Research Associates

The presenters will demonstrate a prototype robot with built-in intelli-

gence. It features 18 degrees of freedom, comprised of two articulated arms, a movable robot head, two CCD cameras for producing stereoscopic views, an articulated cylindrical lower body, and an optional mobile base. The robotic system addresses a broad spectrum of manufacturing demands, including both complex and labor-intensive jobs.

Neural Network Software for Distortion-Invariant Object Recognition
Max B. Reid and Lilly Spirkovska, Research Scientists, Ames Research Center

Ames has created neural network software that performs the complete feature extraction/pattern classification paradigm required for automatic pattern recognition. The software is being used in an autonomous robotic vision system which could have extensive application in robotic manufacturing.

Constraint-Based Scheduling
Monte Zweben, Assistant Chief, Artificial Intelligence Research Branch, Ames Research Center

Mr. Zweben will describe the Space Shuttle Ground Processing Scheduling system, which uses artificial intelligence search methods to solve large-scale scheduling problems. The system can be applied to a variety of scheduling problems. In the manufacturing domain, it can help to minimize set-up time or tardiness.

COMPASS: A General-Purpose Computer-Aided Scheduling Tool
Dr. Barry R. Fox, Project Leader, McDonnell Douglas Space Services Co; and Christopher Culbert, Technical Monitor, Software Technology Branch, Johnson Space Center

COMPASS is an powerful, interactive planning and scheduling system with a mouse-driven, X-Windows user interface. It can be used to manage activities subject to timing constraints, ordering constraints, Boolean conditions, and resource availability, and to manage a wide range of resources including tools, electricity, and water.

(Session E2)

Data and Information Management

ELAS: Powerful General-Purpose Image Processing Software
David Walters, Electronics Engineer, Information Systems Division, Stennis Space Center

Originally developed to process Landsat images, the ELAS software package has evolved to handle a vast range of data types including MRI, soil maps, topographic and rainfall data, and sonar images. Mr. Walters will describe applications in such fields as agriculture, forestry, and geology, and will highlight important new enhancements to the software.

TAE Plus: A NASA Tool for Building and Managing Graphical User Interfaces
Martha R. Szczur, TAE Project Manager, Goddard Space Flight Center

Transportable Applications Environment Plus is a WYSIWYG tool for designing, building, and tailoring an application's graphical user interface. Its main component is the WorkBench, which allows the application developer (who need not be a programmer) to interactively construct an application screen's layout and manipulate graphical objects such as menus, buttons, icons, and dials. TAE Plus is used in such disciplines as image processing. simulation, network management, real-time command and control, database management, and office automation.

Instrumentation, Performance Visualization, and Debugging Tools for Multiprocessors
Jerry C. Yan and Charles E. Fineman, Sterling Federal Systems; Philip J. Hontalas, Ames Research Center

As part of a major effort to advance multiprocessor parallel computing performance, NASA Ames is developing techniques to efficiently monitor and visualize parallel program execution. Such techniques will help simplify the debugging and tuning of parallel programs. The presenters will describe various prototype software tools and their incorporation into the run-time environments of hardware testbeds.

The Data Egg: One-Handed Text Entry Without Positional Constraints
Gary L. Friedman, Technical Group Leader, Jet Propulsion Laboratory

JPL researchers have devised a small, handheld unit that allows text entry with only one hand. Dubbed the Data Egg, it can be operated in any position, either autonomously or tethered to a personal computer. This invention will benefit the handicapped and those normally barred from using a computer on the job, such as astronauts and journalists.

(Session E3)

Electronics

Thermoacoustic Refrigeration
Steven L. Garrett and Thomas Hofler, Naval Postgraduate School

The presenters will demonstrate the first practical, autonomous thermoacoustic refrigerator, which employs high-amplitude sound in inert gas to pump heat. Scheduled for flight on the space shuttle, the acoustically-resonant refrigerator has only one moving part, no sliding seals, and uses inexpensive components. Since thermoacoustic refrigerators use no CFCs and have coefficients of performance comparable with vapor compression cycle refrigerators, they are good candidates for food refrigeration and commercial/residential air conditioning applications.

Ambient Temperature Recorder
Larry D. Russell, Electronics Engineer, Ames Research Center

The ATR-4 ambient temperature recorder is a small battery-powered device that records 32 kilobytes of temperature data from four channels, over a range of -40° to +60°C at sampling intervals from 1.88 to 15 minutes. Data is stored in its internal memory for subsequent readout by a personal computer. Developed for use on the space shuttle, the ATR-4 can answer a variety of needs for a small, remote, unattended temperature recorder, such as in transportation of perishables and recording life system or process temperatures over time.

Fiber-Optic Push-Pull Sensor Systems
Steven L. Garrett and David A. Brown, Naval Postgraduate School

The Navy has created fiber optic "push-pull" sensors that greatly enhance the optical fiber's response to the measurand of interest while providing common-mode rejection of spurious environmental effects such as pressure or temperature changes. The presenters will describe several new fiber optic, interferometric accelerometers and acoustic pressure sensors which generate such large optical phase modulations that their signals can be demodulated with inexpensive lasers similar to those used in CD players.

Commercial Capaciflector
John M. Vranish, Electronics Engineer, Goddard Space Flight Center

Goddard researchers are developing a capacitative proximity/tactile sensor with unique performance capabilities for use on space robots and payloads. The simple, robust sensor will enable robots to avoid collisions with humans in orbit and to dock payloads in a cluttered environment. Mr. Vranish will report on NASA's efforts to "spin" this technology off into the private sector.

(Session E4)

Environmental Technology

Water Quality Monitor
Warren C. Kelliher, Langley Research Center

A portable x-ray fluorescence spectrometer developed for the Viking mission to Mars has been adapted for terrestrial use. Called EMPAX (Environment Monitoring with Portable Analysis of X-ray), the unit answers a critical need for on-site, real-time analysis of toxic metal contamination. The government is seeking a commercial manufacturer for EMPAX.

Remote Semi-Continuous Flowrate Logging Seepage Meter
William M. Reay, Virginia Polytechnic Institute and State University, and Harry Walthall, Langley Research Center

The presenters have created a remote semi-continuous flowrate logging seepage meter that enables direct assessment of ground water discharge and associated solute fluxes. It is designed to replace current manually-operated meters.

Calcification Prevention Tablets
G.A. Lindsay, Naval Weapons Center

The subject invention is a slow-release tablet for preventing or removing calcium crust and build-up in pipes and containers that process hard water and other calcium-containing fluids. Extremely effective in sea water, the tablet is biodegradable and nontoxic. It can be used in urinals, commodes, drains, and holding tanks.

Automated Carbon Dioxide Cleaning System
David T. Hoppe, Marshall Space Flight Center

An environmentally-safe cleaning system jointly developed by NASA, the Air Force, and Martin Marietta uses solidified carbon dioxide pellets to blast the surface to be cleaned. The process can be automated using a programmable robot. Results from cleaning a variety of substrate materials has shown the system to be capable of reducing the amount of chlorofluorocarbon-based cleaning fluids and in some cases totally eliminating their use.

(Session E5)

Materials Science

Applications of Biologically-Derived Microstructures
Joel M. Schnur, Head, Molecular Science and Engineering Center, Naval Research Laboratory

Navy scientists have fabricated hollow 0.5 micron diameter cylindrical-shaped microstructures using modified lipids and the self-assembly provided by nature. Potential applications for the microstructures include controlled release of biocide for antifouling paint, composites for electronic and magnetic uses, and high-power microwave cathodes.

Structural Modification of Polysaccharides: A Biochemical/Genetic Approach
Roger Kern and Gene Peterson, Space Biological Sciences Group, Jet Propulsion Laboratory

This presentation will describe the development of unique biological techniques for adapting polysaccharides for use in electronic and optical devices. The ability to manipulate polysaccharides genetically and chemically will have an immediate impact on current commercial applications based on rheological properties, such as materials coatings, pharmaceutical delivery systems, and food additives.

Cryogenic Focusing, Ohmically Heated On-Column Trap
Stephen R. Springston, Department of Applied Science, Brookhaven National Laboratory

Mr. Springston will present a new method for thermally desorbing volatile solutes that have been cryogenically trapped within a capillary. Advantages of this trap for gas chromatographic analyses include fast response, simplicity, and elimination of connections. Other applications include physicochemical studies, sample modulation chromatography, and restrictors for supercritical fluid chromatography.

Study of the Effect of Hydrocarbon Contamination on PFTE Exposed to Atomic Oxygen
Morton A. Golub and Theodore Wydeven, Research Scientists, Ames Research Center

As part of an effort to improve the surface properties of PFTE (commonly known as Teflon™), Ames researchers are using x-ray photoelectron spectroscopy analysis to study the effect of hydrocarbon contamination on PFTE exposed to an oxygen plasma. Their work will lead to the development of better surface-modified PFTE products for the medical and industrial markets.

(Session E6)

Medical Advances

Applications of the Strategic Defense Initiative's Compact Accelerator Technology
Nick Montanarelli, Deputy Direct, Office of Technology Applications, Strategic Defense Initiative Organization

The Strategic Defense Initiative's investment in particle accelerator technology for its energy weapons program has produced small and powerful accelerations with a variety of "spinoff" medical applications. These include a radio frequency quadropole linear accelerator for a cancer therapy unit, a compact induction linear accelerator to sterilize medical products, and accelerators to produce the radioactive isotopes used as radiopharmaceuticals for positron emission tomography.

Acoustically-Based Fetal Heart Rate Monitor
Allan J. Zuckerwar, Langley Research Center, and Dr. Donald A Baker, Baker Guardian Medical Labs

A new fetal heart rate monitor, using piezopolymer pressure sensors on a belt worn by the mother, can identify the fetal heart tone from among competing background signals and, through signal processing, yield a real-time evaluation of the fetal heart rate. The monitor is inexpensive and lends itself to an ambulatory mode of operation, whereby the mother can conduct fetal non-stress tests in her home.

Surgical Force Detection Probe
Ping Tcheng, Charles Scott, and Paul Roberts, Research Engineers, Langley Research Center

A precision electromechanical instrument detects and documents the forces and moment applied to human tissue during surgery. The pen-shaped probe measures just 6 inches long and features a tip with an interchangeable scalpel. A PC-based data system provides signal conditioning, data acquisition, and graphics display.

Correcting Night Myopia with Biofeedback and a Simple Pocket Optometer
Dr. William B. Cushman, Research Physiologist, Naval Aerospace Medical Research Laboratory

Navy researchers are using a pocket optometer to implement biofeedback training to correct night myopia. Although developed to improve pilots' night vision, the lightweight, handheld optometer could benefit others, including children with "student myopia."

Concurrent Government-Industry Workshops 4:30 pm—6:00 pm

(Presenters to be announced)
Agencies holding workshops during this period will include:

- Department of Defense
- Department of Health and Human Services
- Department of Veterans Affairs
- National Aeronautics and Space Administration

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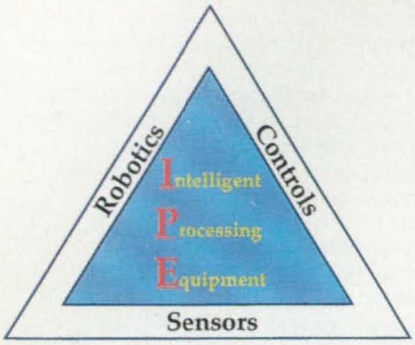

Advanced Manufacturing Technology

IPE Conference Program

The Intelligent Processing Equipment (IPE) Conference will focus on federally-developed innovations in robotics, sensors, and controls that industry can apply to a broad range of manufacturing processes, including machining, forming, welding, heat-treating, inspection, and assembly. Fifteen federal organizations will report on their present R&D efforts in intelligent processing during sessions held concurrently with Technology 2001 symposia in the San Jose Convention Center on Tuesday, Dec. 3 and Wednesday, Dec. 4.

On Thursday, Dec. 5, these presentations will be reviewed and discussed in panel sessions led by select industry leaders in manufacturing. A luncheon featuring a talk by a nationally-recognized expert in advanced manufacturing is also planned for Thursday in the convention center. Proceedings will be published and mailed to attendees after the conference.

The IPE sessions are open to all Technology 2001 registrants at no additional charge. Technology 2001 registrants are also invited to attend the Thursday luncheon, which will involve a small fee for food costs. Further information on the luncheon will be mailed to all Technology 2001 preregistrants prior to the show, and will also be available on-site at an information counter in the lobby.

The final program issued at the show will list IPE Conference speakers and meeting room locations. All the meeting rooms are in close proximity, making it easy for registrants to attend portions of both conferences.

IPE Conference Schedule:

Tuesday, December 3

Technical Session
1:00 pm — 3:00 pm

1:00 Department of Agriculture
1:30 Department of Commerce
2:00 Department of Energy
2:30 Environmental Protection Agency

Technical Session
4:30 pm — 6:00 pm

4:30 Federal Emergency Management Agency
5:00 Department of Interior
5:30 NASA

Wednesday, December 4

Technical Session
8:30 am — 10:30 am

8:30 National Institutes of Health
9:00 National Science Foundation
9:30 Department of the Air Force
10:00 Department of the Army

Technical Session
1:00 pm — 3:00 pm

1:00 Department of the Navy
1:30 Defense Advanced Research Projects Agency
2:00 Defense Logistics Agency
2:30 Strategic Defense Initiative Organization

Thursday, December 5

Industry Review Panels
8:00 am — 11:00 am

8:00 Robotics Panel
9:30 Controls Panel

IPE Luncheon
11:30 am — 1:00 pm

Industry Review Panels
1:30 pm — 4:30 pm

1:30 Sensors Panel
3:00 IPE Summary Session

For further information on the IPE Conference, contact Robert Schwinghamer at (205) 544-1001.

Visit The "Garage"

While you are in San Jose, be sure to visit the Technology Center of Silicon Valley's new interactive exhibit center, called the Garage (after the place where high-tech companies such as Apple Computer began). Located across the street from the San Jose Convention Center, the Garage features informative hands-on exhibits in the areas of space technology, microelectronics, materials, robotics, and biotechnology. Technology 2001 attendees are entitled to a discounted admission rate of $5. You can obtain tickets on the concourse level of the convention center during all three show days.

The Garage contains a 9-foot-square version of a microchip. This exhibit lets you ask a question and then watch it process the answer. As different sections light up, the screen explains how the computation is being made.

Reserve Your Place At Technology 2001 Today

Save time and money: Preregister for Technology 2001 using the convenient form below. Mail the completed form with check payable to the Technology Utilization Foundation, or fax it with credit card information to (212) 986-7864 (VISA and Mastercard accepted). To register by phone, call (800) 944-NASA. Government organizations may register using a purchase order. **Deadline for preregistration is November 8.**

Choose from four types of registrations:

- Complete Registration—includes technical sessions, workshops, and exhibits for all three show days; tickets to the opening reception on Monday, Dec. 2 and the Technology Transfer Awards Dinner on Wednesday, Dec. 4; and a copy of the Technology 2001 proceedings.
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	By 11/8	On-Site
Complete Registration	$300	$325
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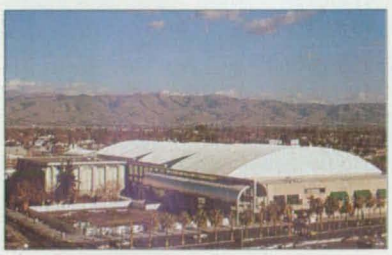
Federal government employees are entitled to a 50 percent discount on above prices. Discounts are also available to groups of ten or more; call (212) 490-3999 for details.

Tickets to the Technology Transfer Awards Dinner may be purchased separately for $150 each using the preregistration form or by calling (212) 966-3100. Preregistrants can pick up their badges and reception/dinner tickets at the San Jose Convention Center, 150 West San Carlos St., during the hours listed below. Registration confirmations will be sent via mail.

On-Site Registration Hours

Monday, December 2	8:00 am - 5:00 pm
Tuesday, December 3	7:00 am - 4:00 pm
Wednesday, December 4	7:00 am - 4:00 pm
Thursday, December 5	7:00 am - 3:00 pm



The new San Jose Convention Center is situated in the heart of Silicon Valley.

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Hotel space is limited, so act early to secure these special conference rates:

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Fairmont Hotel (headquarters hotel) (800) 527-4727	$105	$105
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The Fairmont and Hotel De Anza are within walking distance of the Convention Center; the Hyatt and Red Lion are approx. ten minutes away by Light Rail—San Jose's modern, efficient public transit system. When making reservations, you must mention Technology 2001 to obtain the special rates.

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Ground: Hertz Corp. is offering special discounted car rental rates with unlimited mileage. For reservations, call Hertz Meeting Services at (800) 654-2240 and identify yourself as an attendee of Technology 2001, meeting #9208.

Air: Discounted air fares are available to Technology 2001 attendees through American Airlines. Call American Airlines' Meeting Service Desk at (800) 433-1790 and ask them to display Star File #S01N1BG. Make reservations as the lowest applicable fare from your departure city and give your mailing address. Nepal Travel Bureau—the official travel agency for Technology 2001—will mail you the tickets. For follow-up inquiries about your tickets, call Nepal Travel at (800) 666-4519.

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The Convention Center is located just three miles from San Jose International Airport, and offers plenty of indoor parking. At the heart of the downtown cultural center, the Convention Center is within easy walking distance of restaurants, shops, and entertainment. For information on cultural activities, attractions, and tours, call the San Jose Convention and Visitors Bureau at (408) 295-9600.

Questions? Call Joseph Pramberger or Justina Cardillo at (800) 944-NASA.

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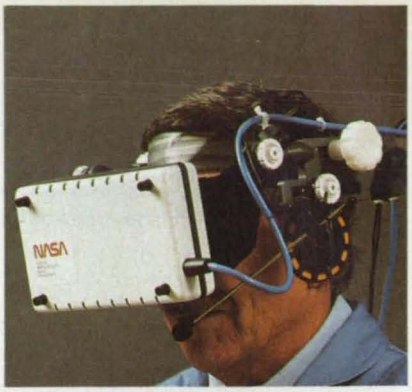
Registrations and awards dinner reservations are transferable, and may be cancelled until Nov. 8, 1991 subject to a $50 cancellation fee. After that date no cancellations will be accepted and no money refunded.

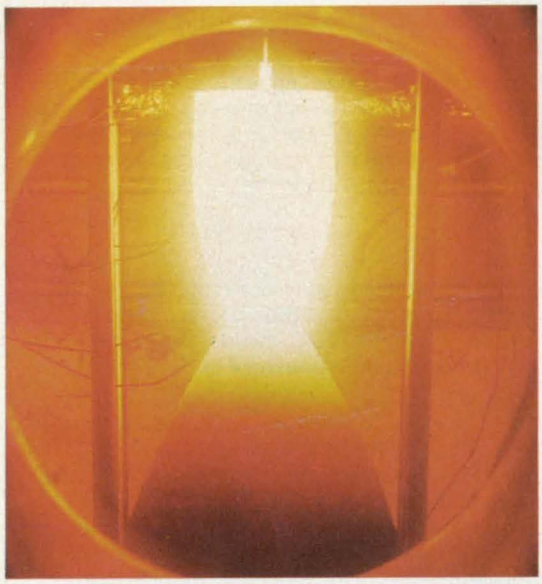
Return with payment to: Technology Utilization Foundation, 41 East 42nd St., Suite 921, New York, NY 10017

Explore The Cutting Edge

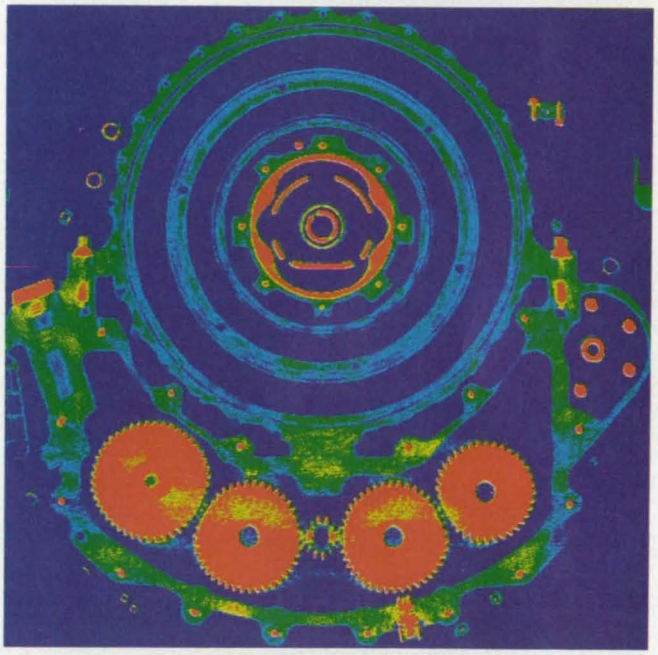
Technology 2001 symposia and exhibits will spotlight the best new inventions from federal laboratories, universities, and leading high-tech companies. Here's just a sample of the hundreds of innovations that await you.



The Ames Research Center exhibit will feature a virtual reality system that combines 3D sound and imagery to create "artificial worlds."

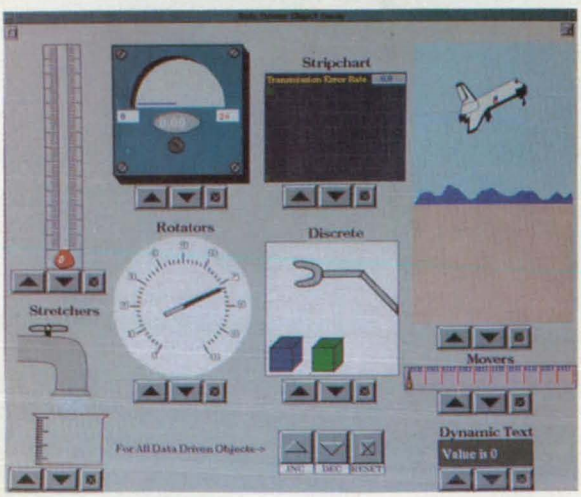


Ultramet will showcase an iridium/rhenium thrust chamber that has been called "the greatest advance in chemical rocket technology in three decades."

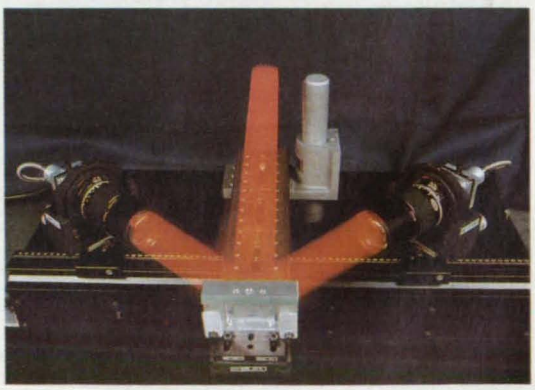


A patented recycling system to be displayed by Sorbilite Inc. converts paper, sawdust, and other waste products into high-quality 3D parts.

The Marshall Space Flight Center will demonstrate an advanced computed tomography system, shown here inspecting the gearing inside a Tomahawk Cruise Missile.



Goddard Center researchers will describe an innovative software tool for building and managing graphical user interfaces.



A major advance in the study and measurement of distortion, stress, and fracture will be shown by Idaho National Engineering Laboratory.

Electronic Systems

Modular VLSI Reed–Solomon Decoder

Multiple chips of the same type would be concatenated for lower cost and flexibility of design.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed Reed–Solomon decoder would contain multiple very-large-scale integrated (VLSI) circuit chips of the same type. Heretofore, a typical VLSI implementation of a Reed–Solomon decoder has been made of as many as five different circuit chips, each of which performs functions from a different stage of the Reed–Solomon decoding process. The principal disadvantage of the prior approach is the high cost of developing the different chips. Because the proposed decoder would contain chips of only one type, the cost of development should be reduced by a factor of about 5. In addition, the proposed decoder would be programmable in the field and could be switched between 8-bit and 10-bit symbol sizes.

In the proposed decoder, each chip would contain sets of logic cells and subcells that perform functions from all stages of the decoding process. The full decoder would then be assembled by concatenating the chips, with selective utilization of the cells in particular chips (see Figure 1). Finite-field multipliers are basic building blocks of Reed–Solomon decoders, and a programmable finite-field, normal-basis finite-field multiplier switchable between 8- and 10-bit operation has been designed for use as a basic building block of each chip.

In turn, each chip would serve as a basic building block of the full decoder. Also as shown in Figure 1, each chip would be divided into eight rows. The first row would be the syndrome-computation cell and would consist of eight identical syndrome subcells. Both the shift registers and the finite-field multipliers in the syndrome-computation cell and the following cells would be made switchable between 8- and 10-bit operation, thereby making the entire decoder switchable between 8- and 10-bit operation. The second row would consist of eight polynomial-expansion subcells. The third row would consist of eight power-expansion subcells. The fourth row would consist of eight polynomial-evaluation subcells, which could also be used to do the Chien search. The fifth row would consist of eight modified-Euclidean-algorithm subcells. The sixth row would contain such miscellaneous cells as counters, shift registers and finite-field multipliers, which would provide "glue logic."

Figure 2 illustrates the configuration of a decoding system that would include the proposed Reed–Solomon decoder. A host computer (which could be a personal computer) would issue commands to the rest of the system. An input module consisting mostly of memory chips would store the received messages. Such operations as formatting, conversion of basis (if both a standard and a dual basis are used), and zero-fill would be performed in the input module. Similarly, an output module would store the decoded symbols and perform such operations as reconversion of basis, reformatting, and zero stripping. A control memory would store all the signals used to control the VLSI chips. (Because of the large number of control signals needed to control VLSI chips, the partitioning of these chips would become very difficult if control-signal generators were to be included.)

This work was done by In-Shek Hsu and Trieu-Kie Truong of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 33 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office-JPL [see page 16]. Refer to NPO-17897.

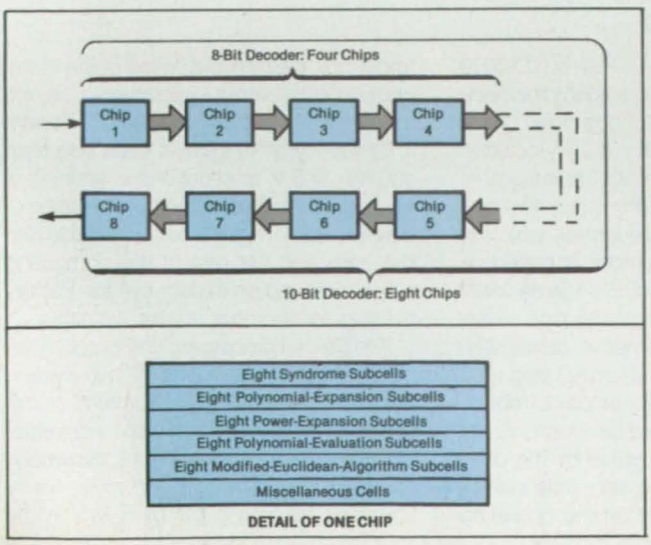


Figure 1. The **Reed-Solomon Decoder** would be an assembly of identical VLSI circuit chips.

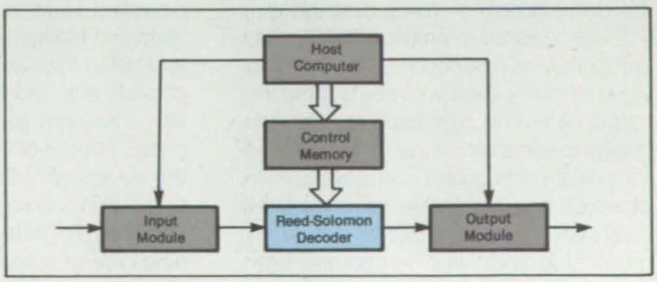


Figure 2. The **Decoding System** would include the decoder of Figure 1 plus four other modules.

Closed-Loop Chopping-Mirror Controller

Mirror position and velocity are electronically sensed and commanded.

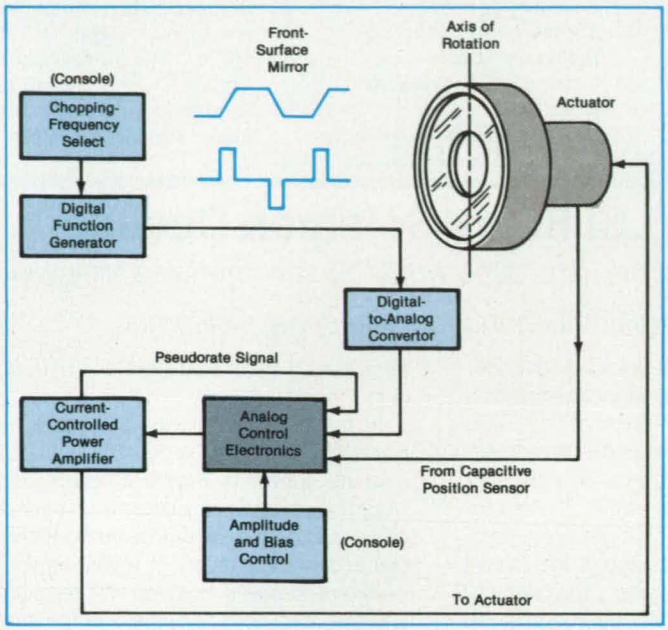
Ames Research Center, Moffett Field, California

The motion of a chopping mirror is controlled very precisely by a feedback circuit originally developed for the mirrors in orbiting infrared telescopes. The new controller enables the selection of different chopping frequencies, angular amplitudes, dwell times, and dwell positions. It also reduces noise and vibration by eliminating mechanical stops and reduces energy consumption in the actuator — an important consideration in infrared telescopes, which are very sensitive to thermal disturbances.

The controller is used with a mirror that oscillates about a diametral axis (see figure). It senses the difference between the commanded position and velocity and the actual position and velocity of the mirror, then responds by sending control currents to the mirror actuator to correct the error.

A digital function generator generates the position- and velocity-command waveforms that repeat at the selected chopping frequency. Regardless of the frequency, the position waveform is a trapezoid designed to hold the mirror during 45 percent of the cycle at one dwell position, 45 percent of the cycle at the opposite dwell position, and 5 percent in each of the two transitions between the two dwell positions.

In principle, the velocity-command signal corresponds in amplitude and phase to the derivative of the position command. The amplitude and phase can be programed, however, if that is necessary to compensate for nonlinearity in the actuator response. Both command signals are converted to analog form and fed to the analog control electronics.



The **Closed-Loop Controller** compares the actual angular position and velocity of the oscillating mirror with the commanded position and velocity. The resulting error signals are used to control the current to the mirror actuator and, consequently, the torque applied to the mirror.

Signals corresponding to the actual mirror position and velocity are derived from the output of a capacitive position sensor. The analog control electronics compare these signals with the command signals. The resulting error signals, along with the integral of the position-error signal, are multiplied by their respective gain factors, then summed. The resulting signal controls the power amplifier that generates the control current for the mirror actuator.

The trapezoidal waveform was chosen because with it the mirror follows a path of minimum energy consumption. The control system responds by accelerating the mirror to the commanded angular velocity at the beginning of the angular transition, then decelerating the mirror to zero angular velocity when it reaches the next dwell position. During the transition, the mirror coasts, except for small corrections in response to velocity errors. The total energy required by the two impulses is about one-fourth that required by a comparable square-wave controller.

This work was done by Kenneth R. Lorell of **Ames Research Center**. *For further information, Circle 84 on the TSP Request Card.*

ARC-11177

Versatile, Fast Computer Core

The core speeds up the development of flight computers.

Goddard Space Flight Center, Greenbelt, Maryland

A versatile computer core serves as a state-of-the-art component and a tool for the development of computing systems that are required to process data rapidly, particularly as part of control tasks that involve relatively large volumes of input and output data. This core exploits new technology to enhance the performance needed in flight computers, the development of which has heretofore been relatively slow because of the limitations of central processing units and memories. Computing and other equipment specific to a flight system can be added around this core to develop flight systems rapidly without incurring the time and monetary costs of designing a new core.

The core consists of a Harris RTX2010 central processing unit, system memory, decoding logic, a watchdog timer, wait-state and timing circuitry. It also includes an RS232 interface for the development of programs and for monitoring the system. The core software kernel, which is stored in read-only memory, is based on the American National Standards Institute's Forth computing language. Inasmuch as Forth is the native (assembly) language of the central processing unit, this kernel provides a compact, robust, fast, interactive software-development environment that is extensible by the user.

The core consumes very little power, the amount depending on the operating frequency, the size and speed of the memory, and input/output requirements. For example, with a memory size of 256 Kb and a frequency of 10 MHz, it uses less than 100 mA at 5 V. In situations in which it is essential to minimize the consumption of power, external signals can be used to turn the core and the rest of the computing system off and on in duty cycles. Battery backup for memory is also available.

The central processing unit executes all native instructions in one or two cycles. Because most native instructions correspond to high-level Forth words, developing in Forth is equivalent to assembly-language programming. However, many "phrases" of words can be optimized by

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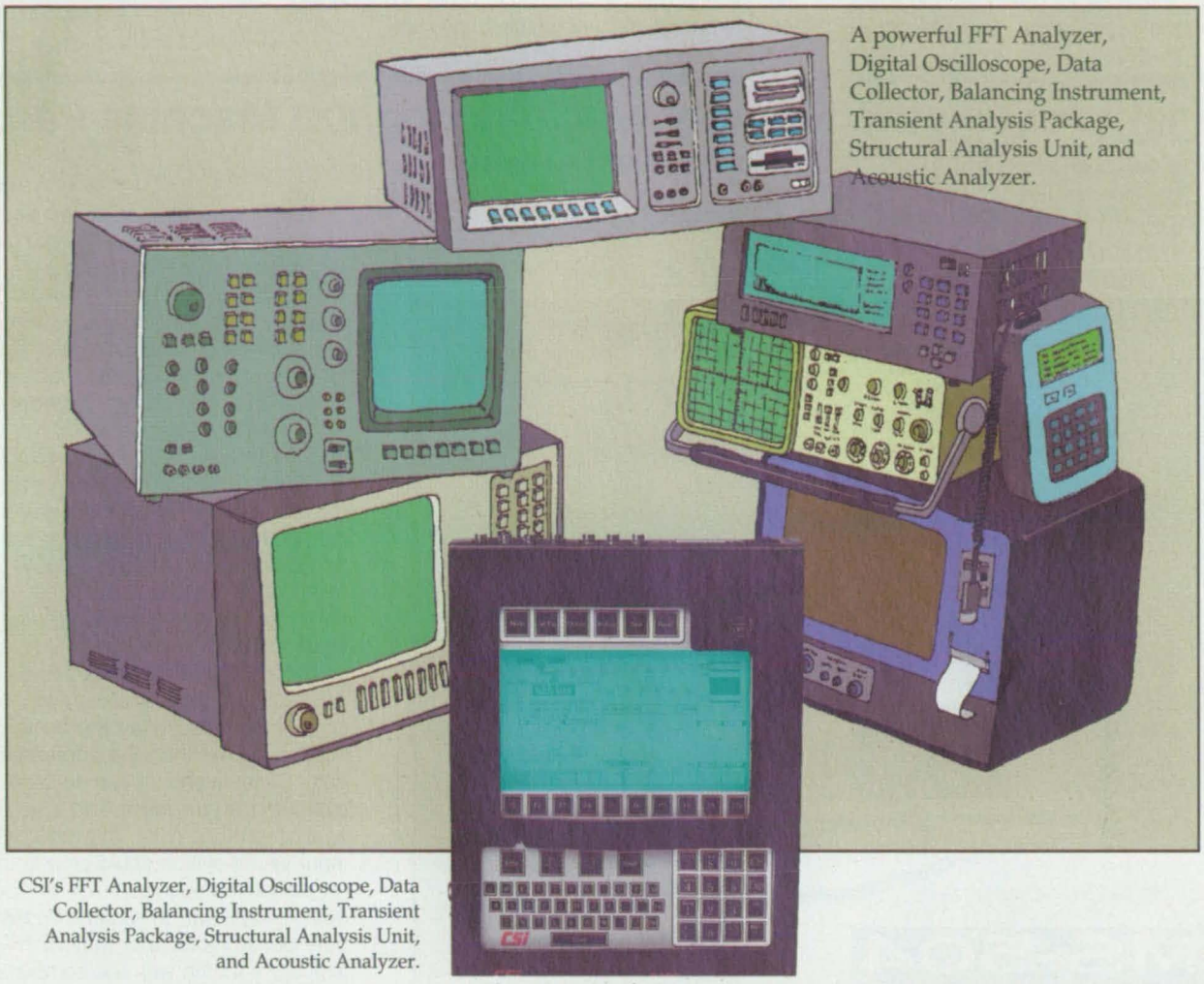

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making them executable in single instructions (opcodes). This kind of optimization is called "code compression." The compression ratio (the number of Forth words that can be executed in one opcode in one clock cycle) typically lies between 1.5 and 3, but it can be as much as 5 in highly optimized segments of code. This much compression enables the central processing unit to have an operation throughput (measured in the number of instructions per unit time) greater than its clock speed. Running at 10 MHz, it can have an average throughput of 15 to 30 million instructions per second (MIPS), with bursts up to 50 MIPS. Previous flight computers have not been able to provide this much throughput in a comparable small size, low power, and low cost package.

This work was done by Douglas Ross of **Goddard Space Flight Center**. *For further information, Circle 26 on the TSP Request Card.*
GSC-13364

Trinary Associative Memory Would Recognize Machine Parts

Some deficiencies of binary representations are overcome.

NASA's Jet Propulsion Laboratory, Pasadena, California

Trinary associative electronic and optoelectronic memories are undergoing development for use in recognizing patterns — for example, to distinguish among different machine parts when stimulated with whole or partial views of the parts. Most associative memories investigated in previous research on artificial neural networks have been based on two-valued logic: either unipolar binary (0,1) or bipolar binary (−1,1). The trinary associative memory combines the merits and overcomes major deficiencies of the unipolar and bipolar logics by combining them in a three-valued (1,0,−1) logic that reverts to unipolar or bipolar binary selectively, as needed to perform specific tasks.

The advantage of an associative memory is that one obtains access to all parts of it simultaneously on the basis of the content, rather than the address, of the data. Consequently, it can be used to exploit fully the parallelism and speed of optical computing. When stimulated with an input vector (which could be a complete or partial representation of the pattern being examined), an associative memory puts out a vector that may or may not indicate a match with the complete vector of one of the patterns stored in the memory.

In the Hopfield neural-network model, well known among researchers in this field, the outer product of a vector with itself is used as a memory matrix for that vector, and thereafter a memory matrix is added for each of the nearly orthogonal stored vectors. Hopfield networks have been implemented by use of bipolar binary numbers in storing vectors and unipolar binary numbers in addressing the memories. An inner-product representation of associative memory has been based on the Hopfield model.

Both the inner product and the Hamming distance have been studied as candidate measures of the convergence of a vector toward one stored in memory (and, therefore, as measures of similarity between patterns or objects represented by the vectors). Usually, the Hamming distance has been used as a measure of dissimilarity, overlooking the role of the inner product in determining convergence. In cases other than that of bipolar binary in-

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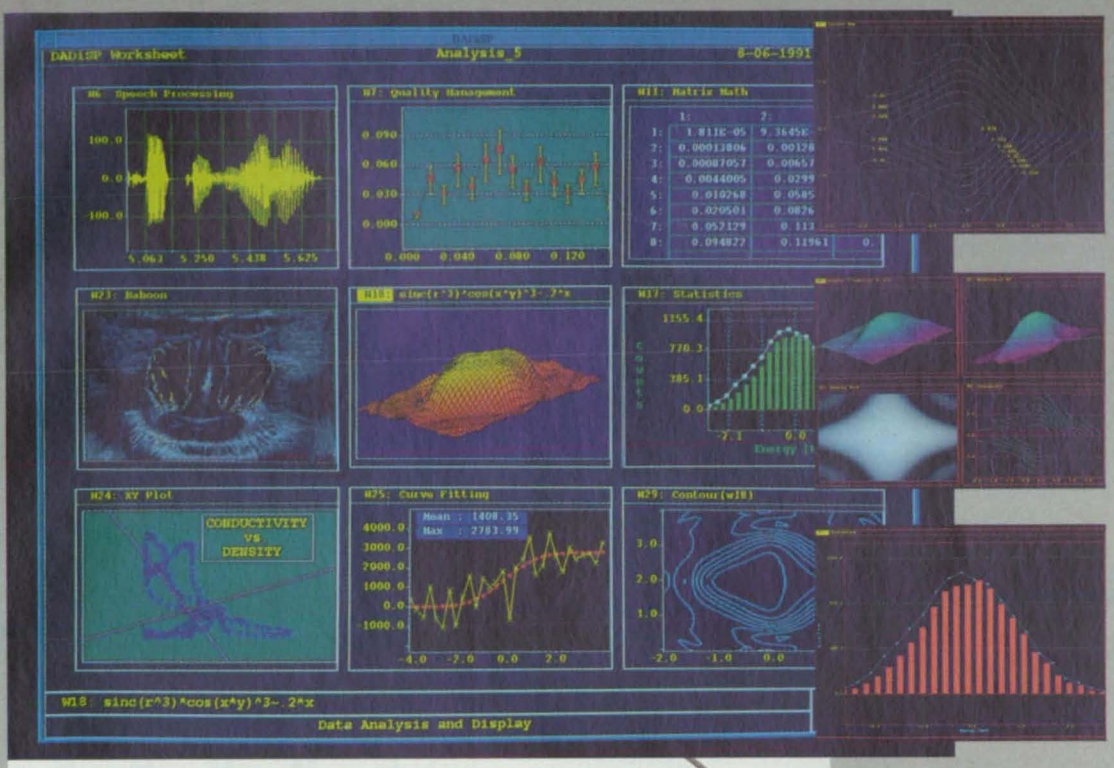

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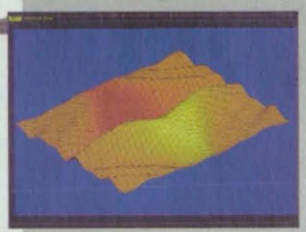

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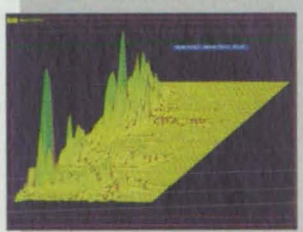

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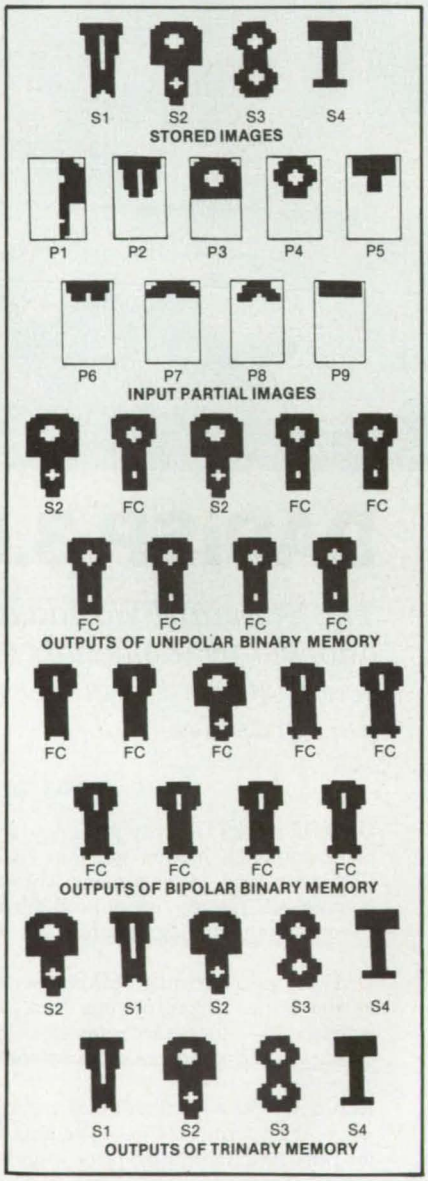
put, the Hamming-distance criterion has been found not to represent directly the continuing matching process of convergence. Inner-product weighting coefficients have been found to play a more dominant role in many representations for determining convergence.

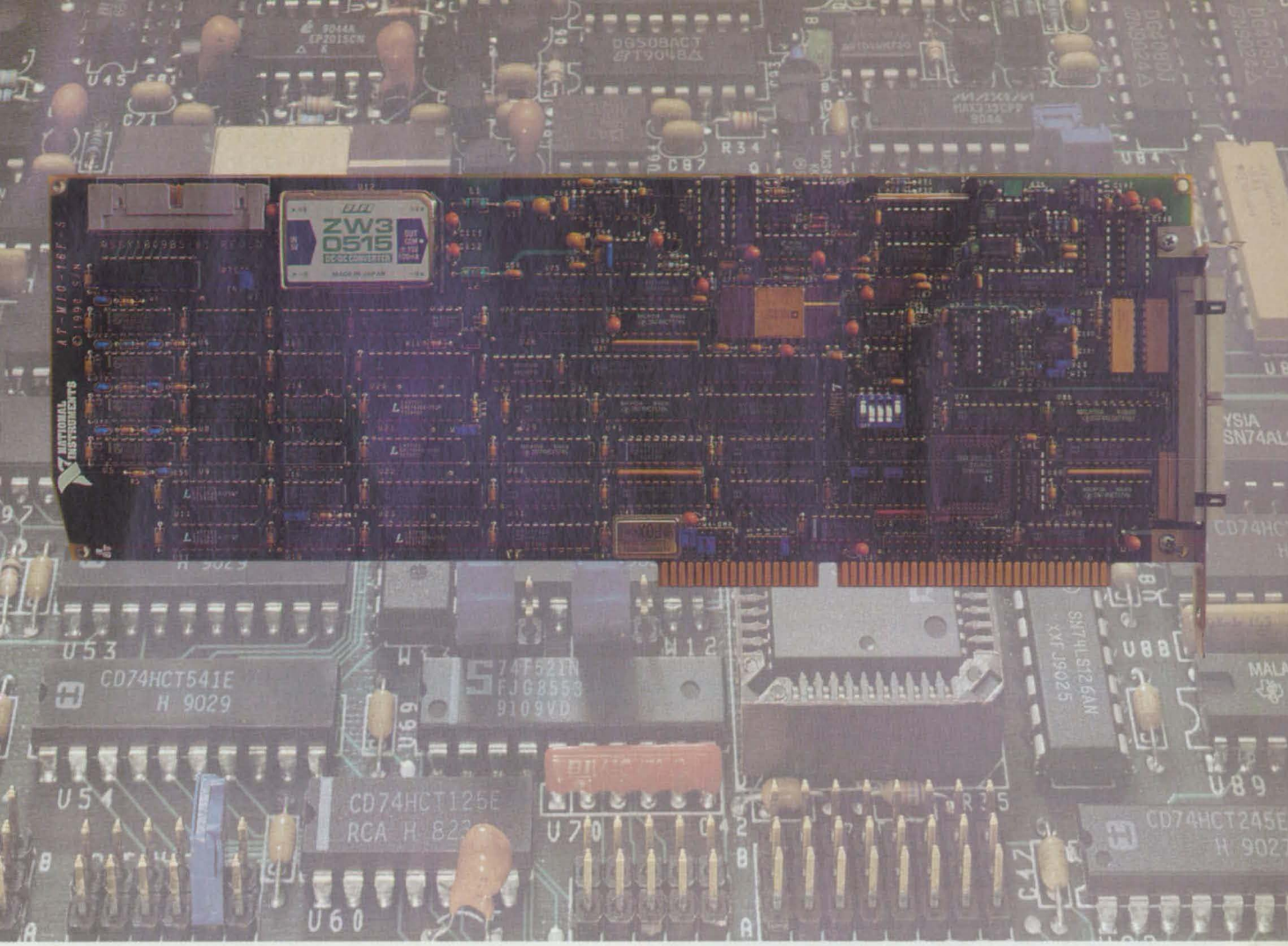
Each of the two binary representations has its own merit. With bipolar input and thresholding, the outcome of the convergence process in an associative memory always agrees with the minimum-Hamming-distance criterion. At the same time, the bipolar binary representation prevents the input from converging to a negative vector. On the other hand, when binary unipolar representation is used, a memory typically seems to recognize partial input, irrespective of its Hamming distance.

In the trinary associative memory, to make the inner product more significant, one can use matching zeros. This, in turn, requires that only those elements of a partial input vector that are in common with a stored vector be represented in bipolar binary, while the remaining elements (representing the unknown components of the input vector) are set to zero. The inner product that corresponds to the input vector is thereby made to equal the number of known elements. Thereafter, one can apply thresholding to accelerate convergence and to avoid convergence to the negative vector. To measure closeness, Hamming distance should be used only for the known elements and not for the whole vector. Thus, in the first iteration, the unknown portion of the input is kept inert. Only after the first iteration is the input vector represented in bipolar binary to accelerate convergence.

Computer simulations have been performed to compare the abilities of trinary and binary associative memories with inner-product thresholding to recognize two-dimensional patterns when stimulated



Nine Partial Images P1 through P9 (each 11 by 20 picture elements), were used to prompt each of three associative memories in a computer simulation. Complete patterns S1 through S4 were stored in the memories. The outputs of the binary associative memories converged to the correct pattern, S2, in only two cases but showed false convergence (FC) to stored or erroneously synthesized patterns in the other cases. The outputs of the trinary associative memory converged to the correct patterns in all nine cases.



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AT-MIO-16H-9 AT-MIO-16H-25	AT	16 SE 8 DI	100,000	12	±10, ±5, 0 to 10	1, 2, 4, 8	2	12	8	3	✓ ✓	✓ ✓	✓ ✓	✓ ✓		✓ ✓
AT-MIO-16L-9 AT-MIO-16L-25	AT	16 SE 8 DI	100,000	12	±10, ±5, 0 to 10	1, 10, 100, 500	2	12	8	3	✓ ✓	✓ ✓	✓ ✓	✓ ✓		✓ ✓
Lab-PC	XT	8 SE	62,500	12	±5, 0 to 10	1, 2, 5, 10, 20, 50, 100	2	12	24	3	✓	✓	✓	✓		✓
PC-LPM-16	XT	16 SE	50,000	12	±5, 0 to 10 ±2.5, 0 to 5	1	–	–	16†	3	✓	✓	✓			
AT-DIO-32F PC-DIO-96 PC-DIO-24	AT XT XT	– – –	– – –	– – –	– – –	– – –	– – –	– – –	32 96 24	– – –	✓ ✓ ✓	✓ ✓ ✓	✓ ✓ ✓			✓ ✓
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by parts of those patterns. As illustrated in the figure, the trinary memory gave correct outputs, while the outputs of the unipolar memory were mostly erroneous and those of the bipolar memory were entirely erroneous.

This work was done by Hua-Kuang Liu, of Caltech, Abdul Ahad S. Awwal of Wright State University, and Mohammad A. Karim of the University of Dayton for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 93 on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

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Refer to NPO-17850, volume and number of this NASA Tech Briefs *issue, and the page number.*

Mode-Switching Algorithms for Antenna Servocontroller

Perturbations caused by switching between modes are expected to be reduced.

NASA's Jet Propulsion Laboratory, Pasadena, California

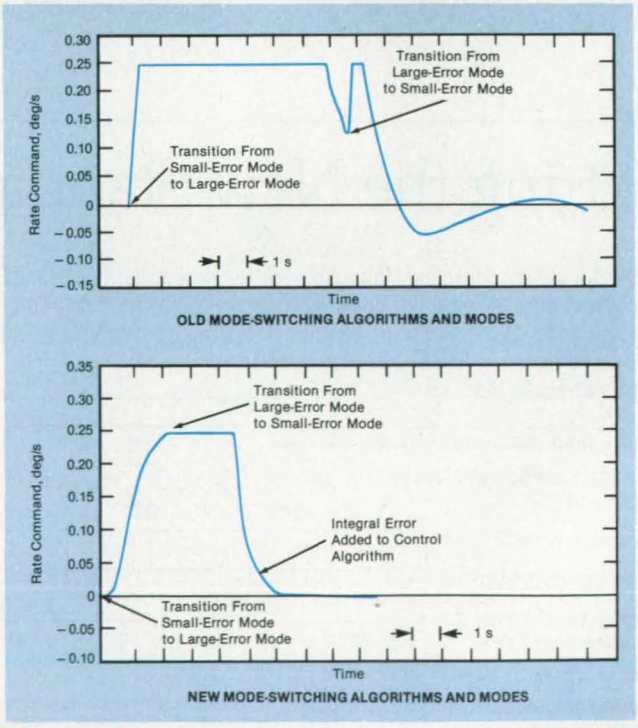
New algorithms have been proposed to reduce acceleration and velocity perturbations caused by transitions between the control modes of a servocontrol system. The system in question aims a 70-m-diameter antenna. It is desirable to reduce these perturbations because they excite vibrations in the antenna structure, thereby increasing the time required to aim the antenna in a new direction and contributing to mechanical wear in the antenna-aiming mechanisms.

The servocontrol system consists of a position-control loop closed around a rate (velocity)-control loop. The rate loop is an analog type-I controller. A rate command (voltage) from the position-loop controller is compared to filtered tachometer feedback rate (voltage) to create a rate error. The rate loop adjusts the actuator-command signal to null the rate error, causing the antenna to turn at the commanded rate.

The position loop is closed by a digital computer called the "antenna servocontroller" (ASC), which is a type-II controller that positions the antenna on the basis of position commands. Three control modes are effected via algorithms that reside in the ASC: (1) a slewing mode called the "large-error" mode; (2) a computer tracking mode called the "small-error" mode; and (3) a precise tracking mode called the "precision" mode. The large-error mode is used to slew the antenna over large angular displacements. The small-error mode is used to track position commands with encoder feedback. The precision mode is used to track a precise positioner, by use of an optical link (an autocollimator) as a position-feedback device.

In the new mode-switching algorithm, a transition from the small-error mode to the large-error mode is made when the position command requires a large angular motion. A transition from the large-error mode to the small-error mode is made when the position error is small. The logic for transitions between the small-error and precision modes remains the same as the old mode-switching logic.

The large-error mode was modified for use with the new mode-switching algorithms and separated into two parts: the new large-error mode and the modified small-error mode. The new large-error mode



Perturbations in a Rate Command occur at transitions between small- and large-error control modes. The transitions are smoother with the new mode-switching algorithms aznd control modes. These plots represent the simulated rate-command responses to a 1° step change in a position command.

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accelerates the antenna from the small-error mode to the maximum slewing rate by use of a digital Bessel filter. The modified small-error mode is one of two submodes of a new small-error mode and is a type-I controller. It decelerates the antenna from the maximum slewing rate and makes a transition into the other small-error submode, which is a type-II small-error mode. It makes this transition by "turning on" the integral-error state in a state controller. Simulations showed that the combination of the new switching algorithms and modified control modes should provide smoother transitions between the small- and large-error modes with fewer acceleration and rate perturbations (see figure).

The switching between the small-error and precision modes was improved by using the same Bessel filter as in the large-error mode and by matching control gain. The misalignment error was filtered to provide smoother and more-stable transitions. Simulations showed improved stability, robustness, and smoothness of transitions between the small-error and precision modes.

This work was done by Jack A. Nickerson of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 106 on the TSP Request Card.*
NPO-17489

Robot Grasps Rotating Object

Advanced techniques for sensing and control are combined.

NASA's Jet Propulsion Laboratory, Pasadena, California

An experimental robotic system semiautomatically grasps a rotating object, stops the rotation, and pulls the object to rest in a fixture. The system, based on a combination of advanced techniques for sensing and control, was constructed to test concepts for the robotic recapture of spinning artificial satellites. Potential terrestrial applications for the technology to be developed with the help of this system could include tracking and grasping of industrial parts on conveyor belts, tracking of vehicles and animals, and soft grasping of moving objects in general.

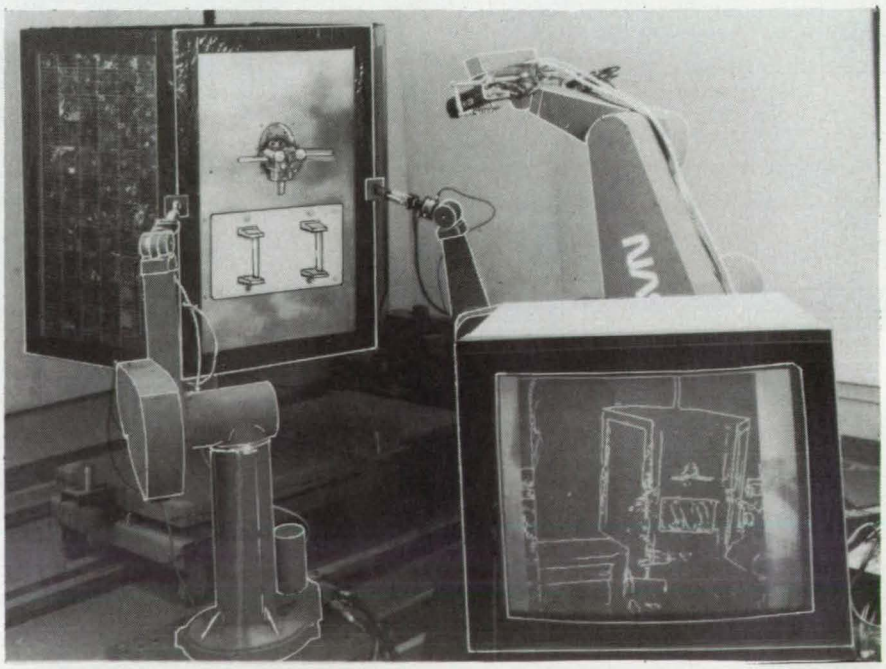
The system (see figure) consists of a sensing-and-perception (S&P) subsystem and a manipulator-control-and-mechanization (MCM) subsystem. The S&P subsystem acquires and tracks the position, orientation, linear velocity, and angular velocity of the spinning object [in this case, a 350-lb (159-kg) mockup of a satellite] and sends tracking data to the MCM subsystem. The S&P subsystem includes charge-coupled-device video cameras, video digitizers, frame buffers, a custom-made "pipeline" video-data processor that finds high-contrast edges in the video images, and buffers that store the output of this processor. The S&P subsystem also includes a microcomputer programmed to control the other S&P equipment and to perform the various computing tasks involved in acquisition, tracking, and the analysis of images.

The MCM subsystem grapples the spinning object and brings it to rest without exerting excessive forces on the object or on itself. This subsystem includes two robot arms with hands that include special grappling tools mounted on pneumatically driven parallel fingers. A microcomputer that communicates with the S&P microcomputer and with the robot-controlling microprocessors performs the control computations for each arm. Data from force and torque sensors on the robot arms are passed back to the computers via the robot-controlling microprocessors.

Ultimately, of course, it would be desirable to develop a robotic system that could acquire a view of the rotating object, track it, grasp it, and bring it to a stop, all automatically. A fully autonomous acquisition algorithm is being developed, but at present, acquisition requires so much computation that it cannot be performed rapidly enough on currently available computers to keep up with a moving object in real time. Therefore, the experimental system is designed to execute a semiautomatic acquisition procedure: A human operator guides the system into an approximate overlap of each video image of the rotating object with a superimposed wire-frame video image that represents the state of the rotating object in the mathematical model of the object in the computer. Once the desired overlaps are achieved, the operator commands the system to begin the automated operations of tracking, grasping, despinning, and pulling into the fixture.

In experiments, the system has successfully grappled the satellite mockup at rotational speeds up to 2 rpm. At higher speeds, delays in communication and inaccuracies in the control subsystems cause the robot hands to miss the grasping pads on the mockup. The use of faster computers and improved robot-control software should improve the grappling capability and help reduce the transient grappling forces.

This work was done by Brian H. Wilcox, Kam S. Tso, Todd E. Litwin, Samad A. Hayati, and Bruce B. Bon of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 90 on the TSP Request Card.*
NPO-18016



The Test Bed of the NASA Telerobot Project is being used to investigate the robotic capture of a spinning mockup of a satellite. The technology is also potentially applicable to industrial robots and robotic vision systems that are required to acquire, track, and possibly grasp moving objects.

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Characterizing Computers and Predicting Computing Times

Times necessary to run given programs on given computers can be predicted fairly accurately.

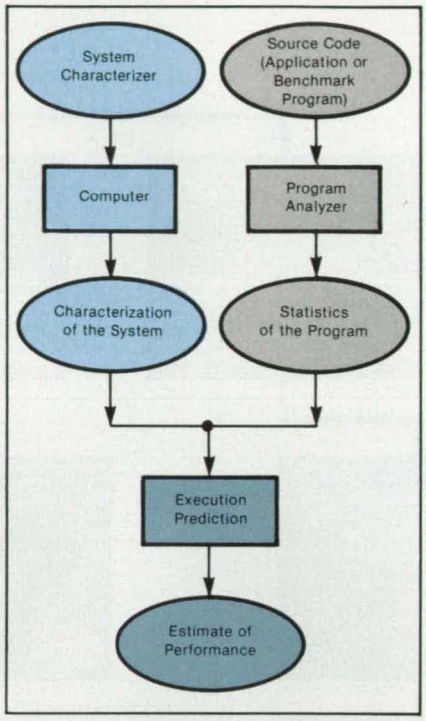
Ames Research Center, Moffett Field, California

An improved method for evaluation and comparison of computers running the same or different FORTRAN programs has been devised. It enables one to predict the time necessary to run a given "benchmark" or other standard program on a given computer, in scalar mode and without optimization of the codes generated by the compiler. Such "benchmark" running times are principal measures used to characterize the performances of computers; as such, they are of interest to designers, manufacturers, programmers, and users.

Heretofore, the time to execute a benchmark program on a specific computer had to be determined either by running that program on that computer or else by extrapolation from similar benchmark programs for which data were available. Such "benchmarking" often gives an oversimplified measure that is not particularly useful in comparing performances, extrapolation is difficult if not impossible in many cases, and neither benchmarking nor extrapolation measures the structural characteristics of equipment and programs that affect running times.

In a sense, the new method also involves benchmarks and extrapolation, but with an important difference: it breaks down the problem into smaller measurable components in a process that involves the characterization of the computer and the separate characterization of the benchmark or other program, followed by a synthesis that yields a prediction of the performance of the computer running that program (see figure). For the characterization of the computer, the method prescribes one or more "system characterizers," which are computing experiments that detect, isolate, and measure features of the hardware and the software that runs on it. These features describe the system and determine its performance. The accuracy of the description depends on the number and detail of the experiments. For example, a very coarse descriptive model would be one in which all floating-point operations are represented by only one parameter. The same system characterizer, consisting of FORTRAN program constructs, is run on all the computers of interest. The output produced by the characterizer constitutes the data base that will be used to estimate performance.

For the characterization of the benchmark or other application program, the method prescribes an algorithm called the "program analyzer," which analyzes the program to determine how it will be executed in the given system. The parameters chosen for this decomposition are exactly the set of operations supported by the programming language. Thus, the implementation of the program analyzer requires the modification of the compiler to obtain the static properties of the application program and the "instrumentation" of the source or object code to produce dynamical statistics at run time. These properties and statistics enable the prediction of the dynamic behavior of the application program.



The System Characterizer and the Program Analyzer acting in conjunction with the execution predictor, predict the time required to execute a given FORTRAN application program on a given computer.

The execution predictor is the algorithm that combines the outputs of the system characterizer and the program analyzer. It predicts the total execution time for a program as a linear combination of execution times of its component operations. Thus far, the method has yielded fairly accurate predictions of the execution times of 10 benchmark programs on 10 different computers.

This work was done by Rafael H. Saavedra-Barrera of the University of California for **Ames Research Center**. *Further information may be found in NASA*

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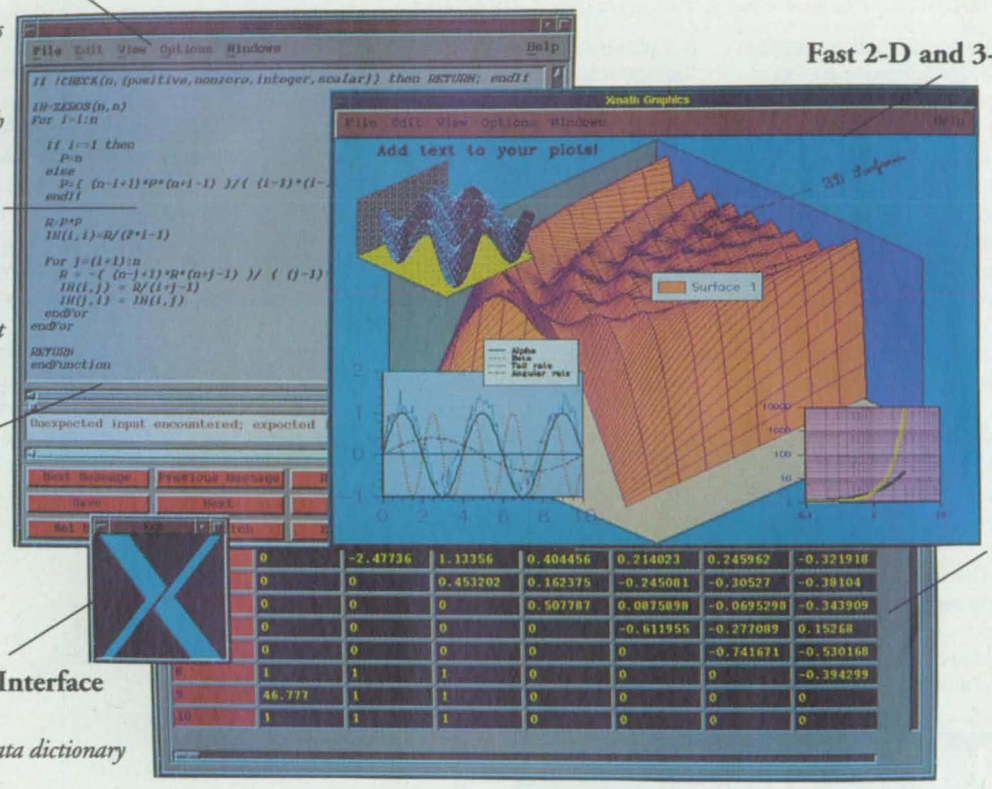

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Three-Dimensional Acousto-Optical Spectrum Analyzer

Integration in the third dimension (time) yields superfine resolution.

NASA's Jet Propulsion Laboratory, Pasadena, California

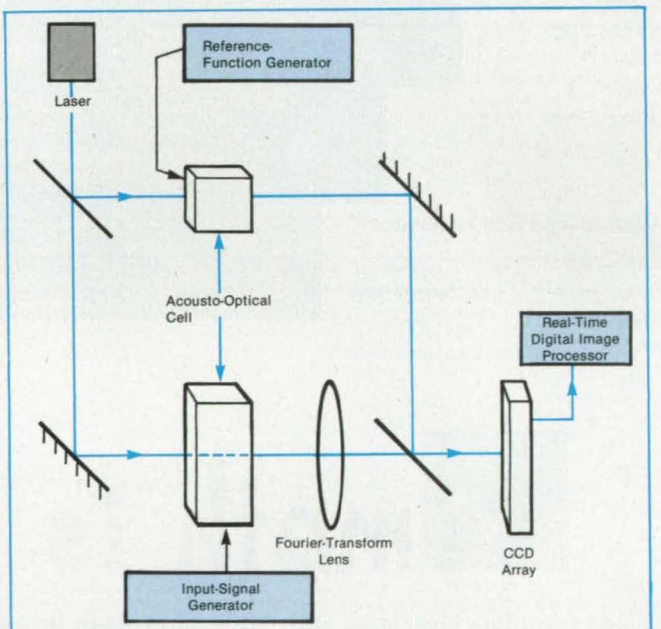
An experimental acousto-optical Bragg-cell spectrum analyzer achieves subhertz frequency resolution. This system represents an extension to three dimensions of the two-dimensional spectrum-analyzer concept described in the preceding article, "Two-Dimensional Acousto-Optical Spectrum Analyzer" (NPO-18092). In this as in the preceding system, the first and second dimensions are the two spatial dimensions of a charge-coupled-device (CCD) imaging array. The third dimension is time, as sampled at the frame rate of the CCD array.

Figure 1 is a schematic illustration of the three-dimensional spectrum analyzer. As in the two-dimensional version, (1) the signal is first focused in one direction by a Fourier-transform lens (this is called "space integration") onto the CCD array to obtain coarse frequency resolution, then (2) the focused signal is mixed with a reference function in the form of a sampled distributed local oscillator and integrated in time on the CCD array to obtain fine frequency resolution in the perpendicular direction. The fine frequency resolution is typically about 100 Hz.

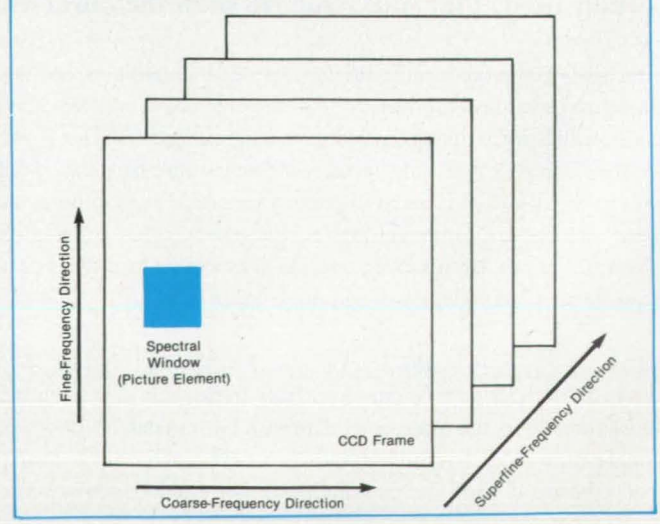
The three-dimensional spectrum analyzer includes a real-time digital image processor, which "grabs" each frame of the two-dimensional image of the spectrum produced by the space and time integrations on the CCD array. This processor performs a secondary integration in time in each fine-resolution channel over a sequence of frames. A fast Fourier transform is applied to the sequence of values in each picture element. As a result, each fine-resolution channel is resolved further into channels of subhertz width. This three-dimensional operation would be particularly useful in both quickly identifying a narrow-band radio-frequency signal within a wide initial analysis band and analyzing its subhertz spectral features.

Figure 2 shows the result of an experiment in which the three-dimensional sys-

Figure 1. The **Three-Dimensional Acousto-Optical Spectrum Analyzer** is essentially a two-dimensional acousto-optical spectrum analyzer equipped with a real-time digital image processor that performs a secondary integration in time on the output of each picture element in the CCD array.



THREE-DIMENSIONAL ACOUSTO-OPTICAL SPECTRUM ANALYZER



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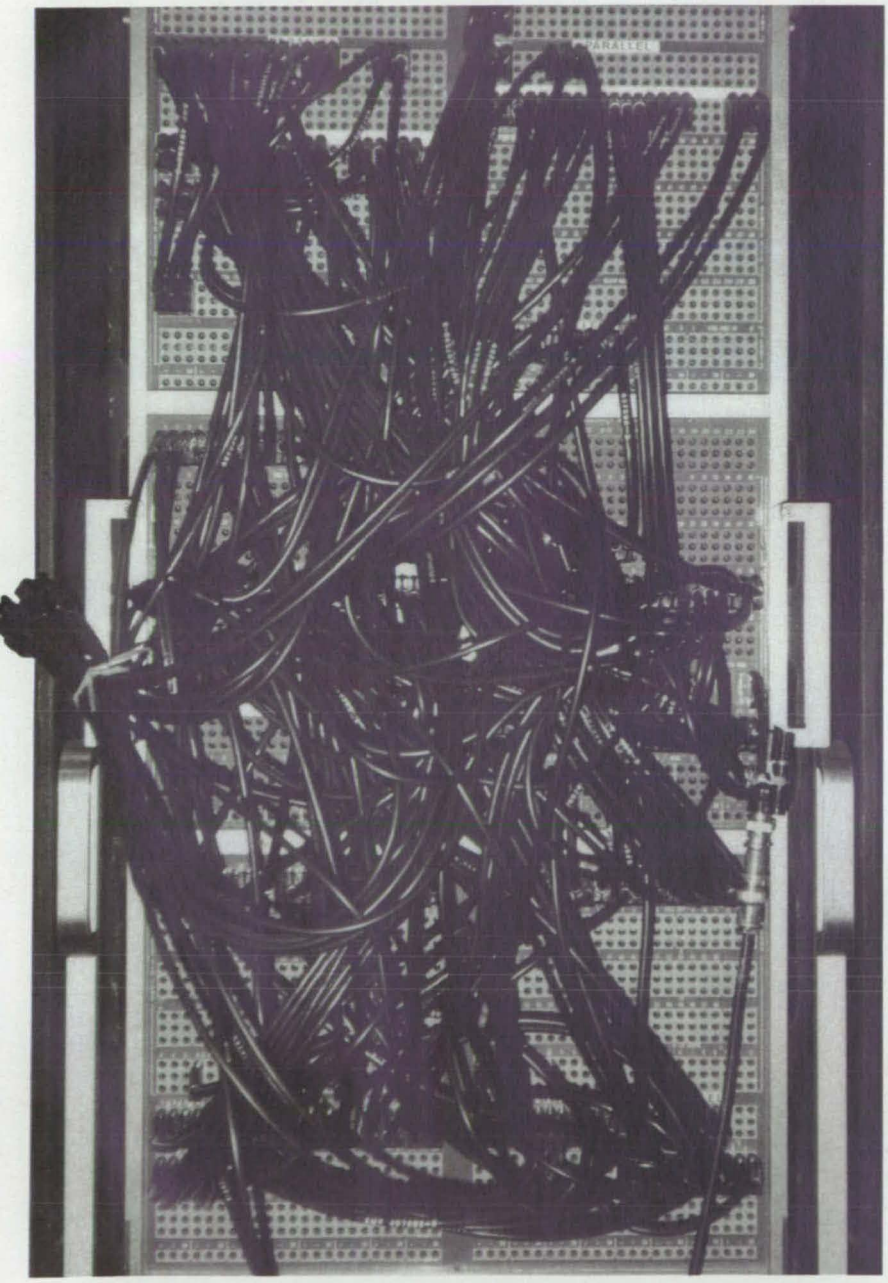

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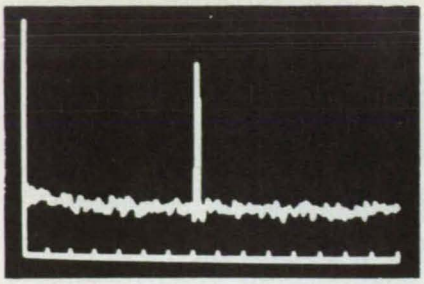


tem was used to analyze a 1,000,941-Hz signal. The CCD frame rate was 30 frames per second, and the secondary integration in time was performed over 512 frames (about 17 seconds). The output spectral peak has a full width at half maximum of only 0.12 Hz.

Figure 2. This Spectrum Containing a Peak was obtained by processing a 1,000,941-Hz signal through the three-dimensional acousto-optical spectrum analyzer. The horizontal scale represents frequency at 1 Hz per division.

This work was done by Homayoon Ansari and James R. Lesh of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 135 on the TSP Request Card.*
NPO-18122

System Acquires and Displays Signal-Propagation Data

The system is flexible and easy to operate.

NASA's Jet Propulsion Laboratory, Pasadena, California

An electronic system acquires, controls the processing of, and displays data from experiments on the propagation of phase-coherent radio signals at frequencies of 12, 20, and 30 GHz. The system offers outstanding accuracy; acquires and displays data and controls associated equipment, all in real time; and includes a hardware and software interface with the user that makes it flexible and easy to operate.

The equipment portion of the system is a rack-mounted unit that includes a custom-made backplane. Circuits of six types are plugged into the backplane: digital input, analog input, digital output, analog output, one that serves as an interface to a hybrid digital/analog receiver, and one that contains a microprocessor-based controller (see Figure 1). The controller serves as the interface between the other circuit cards and a personal computer that, in turn, serves as the hardware interface between the system and the user.

The primary function of the controller is to sample data from the input cards at a rate, commanded by the user, between 10 and 100 Hz. All of the input cards are synchronized with each other via a common sampling-clock signal. After each sampling pulse, the control unit reads the latched value from each card and buffers the data for transmission to the computer. The controller can be configured to return only those data that are from specific channels and that are to be recorded in the disk memory of the computer. By thus reducing the number of data, the data-acquisition system reduces the load on the computer, enabling it to perform other tasks in addition to receiving and processing the incoming data.

The data acquired by the system are transferred to the computer via an "interrupt" service routine and stored in a first-in/first-out buffer memory. A C-language program that is executed as a background process formats the data and transfers them to a file in the disk memory of the computer. The program also enables the user to select, for display and/or processing, a subset of data from a specified group of channels and from a specified interval of time (including data being collected at the moment).

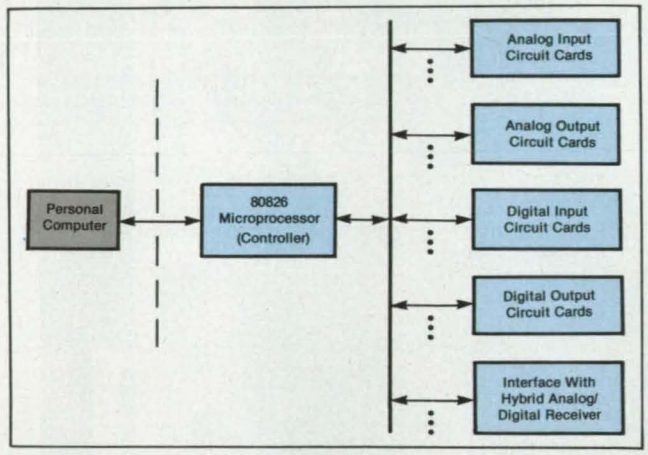


Figure 1. The **Data-Acquisition Equipment** coordinates the flow of data from multiple input channels to the computer.

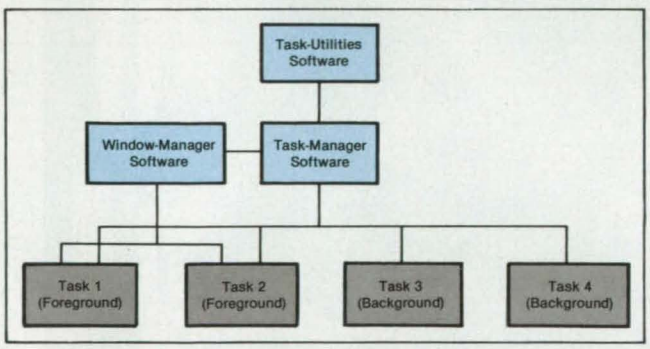


Figure 2. The **Data-Acquisition Software** provides for multitasking and for interactive graphical displays, including easy-to-use windows and pulldown menus with mouse input. This diagram illustrates the relationship between the interactions among the task-manager software, the window-manager software, and the tasks prescribed by the user.

The overall operation of the system is controlled by a multitasking program (see Figure 2) that assists the user with windows, icons, and other graphical display features. The user supervises the system via keyboard and mouse inputs; these inputs are coordinated, and the video outputs are controlled by task-manager software. The task-manager software schedules and dispatches computing tasks, assigning priorities according to prescribed rules.

Window-manager software provides support for the display adapters of the video output terminal of the computer. Functions include swapping video pages with data in storage in the disk memory, selection of the active window, and pulldown menus. Each foreground task has a direct link to the window-manager software; one purpose of this link is to provide the pulldown menus that assist the user in the task. The window-manager software coordinates the mouse input from designated positions on the pulldown menus.

Data can be displayed in a variety of formats, including single traces and colored multiple traces. For each format, the time scale can be varied to display single events or long-term trends. The displayed data can be edited graphically. The rate of sampling and the channels from which data are to be stored in the disk memory can also be chosen via the display software.

This work was done by John C. McKeeman and P. William Remaklus of Virginia Polytechnic Institute and State University for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 9 on the TSP Request Card.*
NPO-18190

Facility Measures Magnetic Fields

Objects are magnetically characterized and, to the extent possible, magnetically compensated.

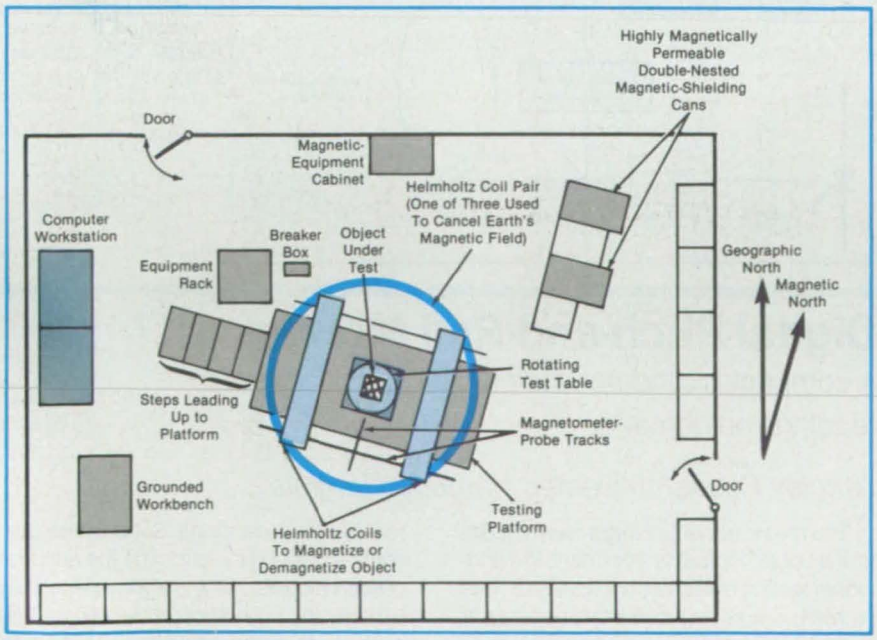
NASA's Jet Propulsion Laboratory, Pasadena, California

A partly automated facility (see figure) measures and computes the steady near magnetic field produced by an object. The facility was designed primarily to determine the magnetic fields of equipment to be installed on spacecraft that include sensitive magnetometers, with a view toward the application of compensating fields to reduce interference with the spacecraft-magnetometer readings. However, because of its convenient operating features and the sensitivity of its measurements, the facility could serve as a prototype for similar facilities devoted to magnetic characterization of medical equipment (e.g., for nuclear-magnetic-resonance imaging), magnets for high-energy particle accelerators, and magnetic materials.

The facility can measure the magnetic field of an object of any size up to about 1 m in its maximum linear dimension. Because of accuracies associated with the computerized data acquisition vs. the old method of manually reading pen-drawn plots, the new system provides three times the sensitivity of the best prior facility of this kind. A computer controls the operations of the measuring equipment, integrates these operations with the acquisition and processing of the measurement data, and produces analyses of the data in nearly real time. The test technician exerts overall control via a computer workstation. "User-friendly" software eases the technician's task by providing menus of options and easy-to-understand instructions.

The object under test is placed on a test table that rotates about a vertical axis to a specified angular position. A magnetometer probe set at a specified horizontal and vertical position measures the three components of the magnetic field. Under the technician's supervision and direct control by the computer, this measurement procedure is repeated for a number of angular positions of the table in rotations about each of the three principal axes of the object under test and for a number of linear positions of the probe, thereby obtaining a map of the magnetic field surrounding the object. To simplify the acquisition, processing, and interpretation of data, the natural magnetic field of the Earth is canceled to the extent practicable: a set of orthogonal Helmholtz coils produces a compensating field, resulting in a 1-m^3 volume of zero ambient magnetic field around the test table.

The three components of magnetic field from each measurement are used to compute the radial component in a spherical coordinate system centered on the axis of rotation in the test object. The computer



The **JPL Magnetics Facility**, housed in a laboratory room, maps the radial component of the magnetic field produced by an object. The facility can measure fields as small as a few nanoteslas.

program performs a fifth-order spherical-harmonic analysis of the radial component of the magnetic field on the imaginary spherical surface on which the measurements are performed. This analysis yields the dipole and quadrupole moments of the magnetic field. Other data products include plots of the magnetic field in various coordinate systems.

The ease of data analysis aids rapid turnaround when it is desired to "compensate" objects (reduce the field by an opposing compensating permanent magnet) to reduce their residual fields.

This work was done by Shawn B. Honess, Pablo Narvaez, and James M. McAuley of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 25 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, NASA Resident Office-JPL [see page 16]. Refer to NPO-18187.

Self-Heterodyne Laser-Spectrum Analyzer

Spectral widths of as little as 100 kHz can be measured.

Goddard Space Flight Center, Greenbelt, Maryland

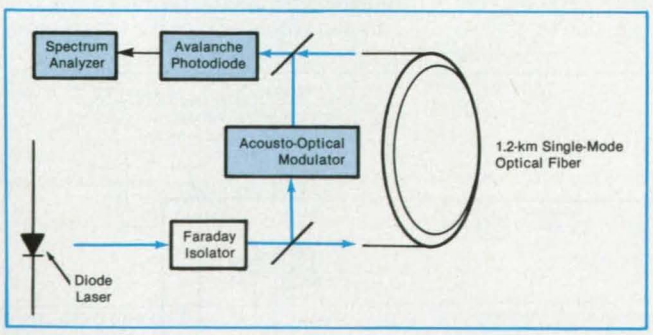
An apparatus measures the spectral widths of the light emitted by GaAs or other narrow-linewidth diode lasers at wavelengths between 800 and 900 nm. Operating on a quasi-homodyne or self-heterodyne principle, the apparatus provides relatively high spectral resolution: it can measure spectral widths of the order of 100 kHz. In comparison, the best resolution obtainable from a Fabry–Perot etalon at wavelengths from 800 to 900 nm is about 12 MHz.

In the apparatus (see figure), the light from the diode laser under test is sent along two arms of an interferometer. An acousto-optical modulator in one arm shifts the frequency of the light in that arm by 200 MHz. The other arm is a delay line that consists of a single-mode optical fiber 1.2 km long. The outputs of the two arms are summed in an avalanche photodiode.

The output of the photodiode is viewed on a spectrum analyzer. The spectrum includes a spike at the 200-MHz beat note and a Lorentzian distribution (a measure of incoherence) around the spike. The half width at half maximum of the Lorentzian component is considered to be the spectral width of the laser light. The fine spectral resolution of this apparatus can provide data relevant to the use of AlGaAs diode lasers in such applications as coherent optical communication through free space and injection seeding of solid-state lasers. The data can also be used to explore the connection between the lifetimes and spectral widths of diode lasers.

This work was done by Babak Saif and Bernard D. Seery of **Goddard Space Flight Center**. *No further documentation is available.*

GSC-13397



The **Heterodyne Laser-Diode Spectrometer** resolves the spectrum of a laser diode to as little as 100 kHz.

Digital Pitch-and-Roll Monitor

A compact inclinometer is precise and prints out readings on demand.

Langley Research Center, Hampton, Virginia

The measurement of angle with respect to the local vertical is important in wind-tunnel testing and other applications. This problem is compounded if it is necessary to make this measurement in two axes simultaneously. In some wind tunnels, models can be set to roll angles over a 360° range and to pitch angles over a reasonably wide range. Sensors are generally employed to determine the attitudes of such models, but it is always necessary to verify the calibration of the sensor(s) in each model before and after a wind-tunnel test. Conventional inclinometers, which are generally used for this task, have distinct disadvantages in weight, size, readability,

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Mechanical Dynamics

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and the like. Other types of angle sensors are available but have either limited range or limited accuracy.

Consequently a small, highly accurate inclinometer has been developed. This inclinometer monitors both pitch and roll simultaneously and can provide printed output on demand. The inclinometer includes three mutually perpendicular accelerometers and signal-conditioning circuitry that converts the outputs of the sensors to digital values of pitch and roll. The accelerometers are mounted on an inclinometer base. Three digital multimeters have been modified to supply power to the accelerometers and digitize their outputs. A small programmable calculator computes the angles, and a printer provides hard-copy output.

The displays of the multimeters provide visual readout of pitch and roll directly in degrees. The system can be operated from 115 Vac or from internal batteries. The system has a resolution of 0.001° and an accuracy of approximately ±0.005°. The computer program provides for using an alternate reference instead of reading absolute angles. This simplifies mounting the inclinometer on a model at some location other than the zero-reference surface.

This inclinometer is based on work done in support of the National Transonic Facility, which has used this inclinometer or its prototype since 1984. In addition to its wind-tunnel applications, this system could be useful in any application involving steady-state, precise sensing of angles, such as the calibration of robotic devices and positioners.

This work was done by Tom D. Finley of **Langley Research Center**, *Jeff Brown of Virginia Governor's School, and Ryland Campbell of Wyle Laboratories. For further information, Circle 148 on the TSP Request Card. LAR-14247*

Books and Reports

These reports, studies, handbooks are available from NASA as Technical Support Packages (TSP's) when a Request Card number is cited; otherwise they are available from the National Technical Information Service.

Research on Controls and Displays for V/STOL Airplanes

Advanced control systems are needed for complicated maneuvers under adverse conditions.

A report describes continuing research into electronic control and display systems for vertical/short-takeoff-and-landing (V/STOL) aircraft. The objective of this research is to develop advanced digital control systems ("fly-by-wire" systems) that will integrate flight and propulsion controls. These systems are intended to enable pilots to perform complicated landing maneuvers, including transitions from horizontal to vertical flight under visual and instrument flight conditions and landing in bad weather on the decks of heaving ships, in confined spaces, and at ill-prepared sites. The thrust of the research described in the report is toward the eventual demonstration of such a system in NASA's V/STOL Research Aircraft (VSRA).

A major technological challenge is posed by the complicated interaction of kinematics, aerodynamics, and propulsive forces and moments during the transition from airborne (horizontal) to jetborne (vertical) flight, as reflected in poor flying qualities and limited control authorities. The pilot's control problem during the transition is aggravated by the general degradation of flying qualities with the increase in dependence on powered lift, and by additional control requirements related to thrust vectoring, and to ignition or switching of flow to lift-augmenting devices. The developmental advanced control systems are intended to integrate the propulsive and aerodynamic controls and displays in ways that minimize the design requirements for excessive propulsive capability, yet enhance the precision of the flightpath and the ability to operate in adverse weather.

This report reviews results of several investigations, in the Ames Research Center Vertical Motion Simulator, of fixed-wing V/STOL aircraft performing decelerating approaches under instrument flight conditions, followed by recovery to confined landing pads or aboard ships. It describes flight experiments to be conducted on the NASA VSRA to substantiate the results of the simulation.

From the simulations, contributions of control augmentation and integrated electronic displays to the operation of these aircraft in adverse weather and aboard ships have been defined. In particular, for the demanding task of a decelerating approach to hover on instruments, aircraft with vectored-thrust capability may require some form of decoupled flightpath and longitudinal-acceleration command in addition to attitude command to achieve satisfactory flying qualities. Further, a cockpit display that integrates situation and command information is essential to success in these operations.

For the vertical landing under such demanding tasks as recovery to a small ship over a range of weather conditions, a velocity-command system is required to achieve satisfactory flying qualities. Operations from larger ships or from austere land-based sites can be accomplished satisfactorily with attitude or, in some cases, with rate-command systems.

On the basis of the results of the simulations, a program has been defined to modify the VSRA to conduct experiments to evaluate these control-augmentation and display concepts in flight. First, a motion-base simulation was performed to evaluate the acceptability of a limited-authority control system for the VSRA that has the potential to create a research capability for in-flight evaluation of advanced V/STOL control and display systems as well as the ability to validate the results of previous simulations. The results of this simulation showed that the limited-authority control system will provide an acceptably capable system within budgetary constraints.

The flight-research program is being conducted in two phases: the first phase is concentrating on developing a data base on the aircraft, and the second phase will include development and evaluation of the integrated control and display concepts for the terminal-area flight regime. A Phase I experiment has been conducted to assess fidelity of the simulation of the YAV-8B Harrier prototype aircraft (of which the VSRA is a modified version) in hover by use of a precise hover task. Pilot ratings, pilot comments, and task-performance measures established correspondence of the simulated and actual YAV-8B in hover. Other Phase 1 experiments have gathered data that are being used to improve the aerodynamic and propulsion mathematical models of the VSRA.

During the Phase II flight program, evaluations of integrated flight and propulsion control modes, formats of head-up displays, and guidance concepts will be conducted during takeoff, transition, hover, and landing operations under visual and simulated instrument meteorological conditions. Subjective assessments by pilots and measurements of precision of tasks and control-authority requirements will be made. Results will be used to define methods to improve the current capability for operation in bad weather, establish operational procedures for use of the advanced systems, and substantiate tentative design criteria obtained from analytical studies and simulation experiments.

This work was done by John D. Foster, Ernesto Moralez, III, James A. Franklin, and Jeffery A. Schroeder of **Ames Research Center**. *Further information may be found in NASA TM-100029 [N88-13359], "Integrated Control and Display Research for Transition and Vertical Flight on the NASA V/STOL Research Aircraft (VSRA)."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700. ARC-12215

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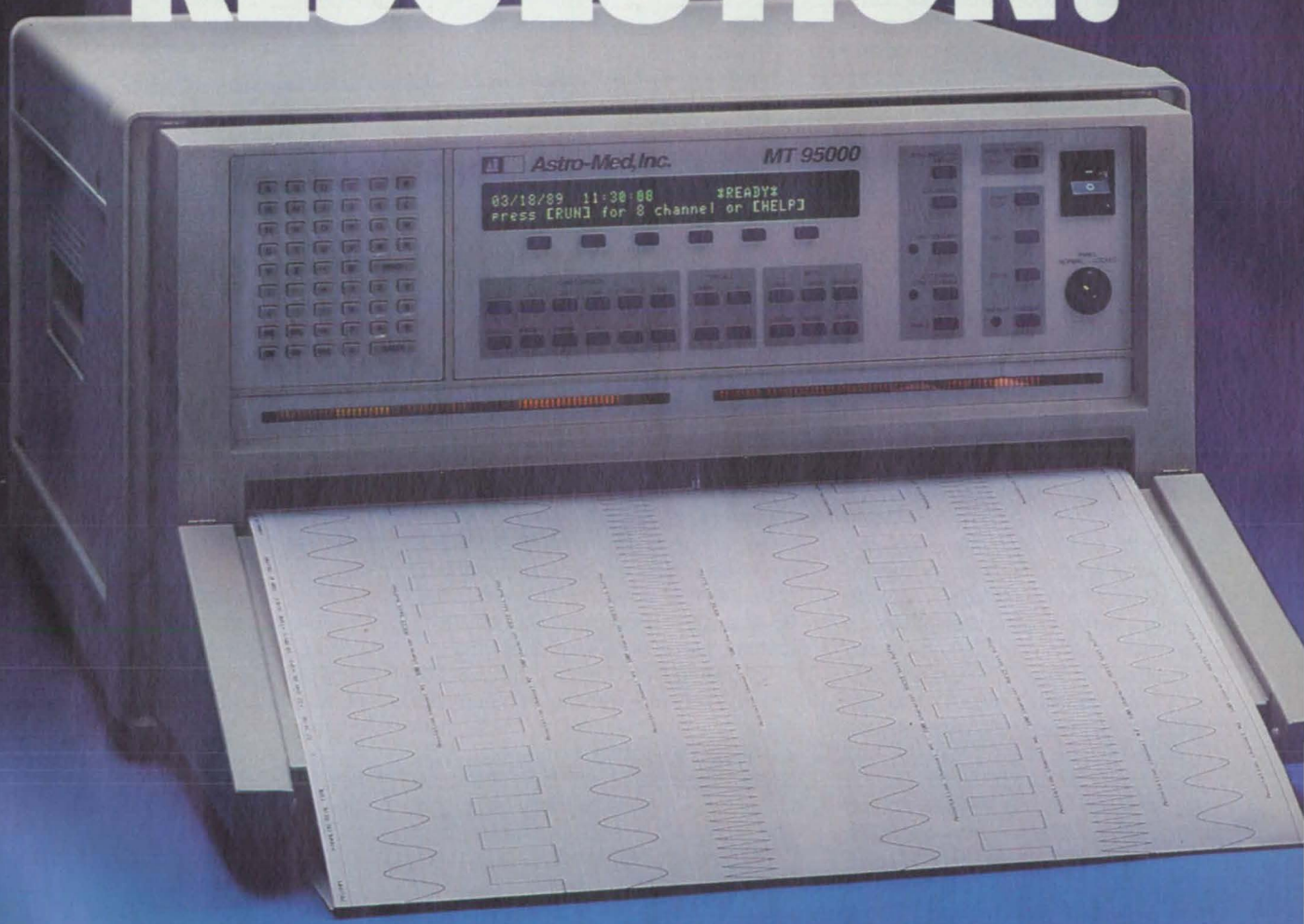

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Physical Sciences

Ultra-High-Spectral-Resolution X-Ray/EUV Monochromator

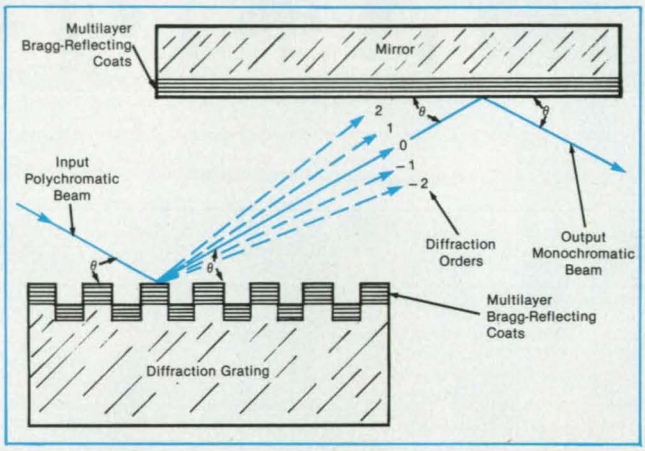
Multilayer Bragg-reflection coats would be combined with diffraction gratings.

Marshall Space Flight Center, Alabama

A proposed monochromator for soft x rays and extreme ultraviolet (EUV) radiation would include diffraction gratings and mirror surfaces coated with alternating layers of high- and low-atomic-number materials to produce Bragg reflection (see figure). The instrument would have moderate throughput and a very high spectral resolution. It would have a relatively low cost and could be constructed and aligned easily.

The multilayer coat on the grating would reflect electromagnetic radiation in a narrow band of wavelengths, with peak reflection at a middle wavelength that would meet the Bragg condition, $n\lambda = 2D \sin\theta$, where D is the center-to-center spacing of successive layers of the same material in the multilayer, θ is the angle between the incident beam and the surface of the grating or mirror, n is an integer that specifies the order of the diffraction, and λ is the wavelength. The grating structure would disperse the selected wavelength band into a series of diffraction orders on either side of the specularly reflected zeroth diffraction order. Where radiation in one of these dispersed orders struck the mirror, the mirror would reflect only the portion of the beam, the wavelength and angle of incidence of which satisfied the Bragg condition. The desired wavelength could be selected by adjusting the angle of the grating and mirror. Typically, the grating and mirror would be maintained parallel to each other, and the angle θ between them and the input beam would be adjusted by a parallelogram linkage.

In some applications, additional slits or other apertures might be required to reject undesired wavelength components. Foil filters could be used at the input to limit the wavelength range accepted.



The **Ultra-High-Spectral-Resolution X-Ray/EUV Monochromator** would depend on Bragg reflection from multilayer coats and diffraction by a multilayer-coated grating to select a narrow wavelength band from an input beam.

In preparation for coating, the mirror and grating substrates would have to be made optically flat to within 1/20 wavelength of visible light, with a root-mean-square roughness of less than 3 Å. Surface roughnesses in the range 0.5 to 3 Å could be produced by advanced flow polishing, float polishing, or ion polishing. Suitable substrate materials include silicon carbide, fused silica, and sapphire.

To make a typical grating surface, 500 to 1,500 lines per mm would be cut into the substrate by mechanical or holographic ruling or by anisotropic etching. Suitable pairs of materials for multilayer coating include rhenium/carbon, tungsten/carbon, and molybdenum/silicon. A typical coat could consist of as few as 20 or as many as 1,000 layers.

By changing the grating and mirror components, one could configure the monochromator to operate at any wavelength from 10 to somewhat more than 400 Å. Alternatively or in addition, the instrument could be constructed with multiple sets of gratings and mirrors arranged like slats in a venetian blind. One grating-and-mirror pair would cover a portion of that range with a wavelength ratio of about $\sqrt{3}$ as the angle of incidence of the input beam varied from 30° to 60°.

The instrument is intended for use with high-intensity x-ray/EUV beams now available from synchrotrons, laser plasma sources, free-electron lasers, wigglers, and the like. Its monochromatic output beam of accurately known wavelength would be very useful in the testing and calibration of x-ray telescopes, x-ray microscopes, photographic films, and photodetectors; in research in biological and biomedical disciplines, x-ray crystallography, the properties and processing of materials, and x-ray lasers; and in x-ray lithography.

This work was done by Richard B. Hoover of **Marshall Space Flight Center**. *For further information, Circle 68 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 16]. Refer to MFS-28500.

Telescope Would Image X and γ Rays

The advantages of focusing optics would be made available at high photon energies.

Marshall Space Flight Center, Alabama

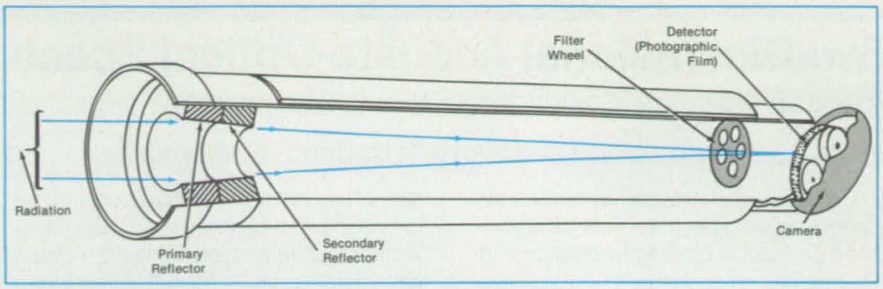
A proposed telescope would form images of sources of γ rays (photon energies from 30 to 100 keV), hard x rays (photon energies from 3 to 30 keV), and soft x rays (photon energies from 0.2 to 3 keV). The telescope would offer the advantages of grazing-incidence focusing optics, which were previously available only at photon energies of less than 10 keV. The telescope

was conceived for use in astrophysical studies in outer space. With modifications, it could be used in terrestrial laboratory vacuum systems to image x or γ rays from pulsed plasmas, for example.

The version of the telescope illustrated in the figure would include two coaxial, spherical, grazing-incidence reflectors. The reflector substrates would be made of sapphire, ground to within 1/20 visible-light wavelength of the desired surface figures, and polished to roughnesses of less than 3 Å root-mean-square. The polished surfaces of both reflectors would be coated with Bragg-reflecting alternating layers of high- and low-atomic-number materials (e.g., tungsten and carbon). The spacing of the layers would be chosen so that, at the wavelength or photon energy at which the image is to be formed, the peak Bragg reflection would occur at the design grazing angle of incidence. The surface figures would be chosen according to the field of view and other optical requirements: typically, the primary reflector would be a paraboloid, while the secondary would a hyperboloid.

At photon energies less than a value (typically, 0.5 keV) that depends on the density of electrons in the high-atomic-number surface layers, the reflectors would operate by conventional grazing-incidence reflection. This means that the telescope would also focus visible light, which is undesired in the intended application. Therefore, to prevent visible light from reaching the imaging detector at the focus, the telescope would include a filter, which would typically be made of aluminum foil 2,500 Å thick on a nickel mesh. Such a filter would be opaque to visible light but highly transmissive for extreme-ultraviolet and higher-energy photons. This filter could be mounted in a wheel along with other foil filters designed to isolate different portions of the soft x-ray spectrum. Thus, by rotation of the wheel to bring one of the filters into the focused beam, one could select an image in x rays or hard γ rays (formed by Bragg reflection) or by soft x rays (formed by conventional grazing-incidence reflection).

The imaging detector could be photographic film or any of a variety of arrays of electronic γ-ray or x-ray detectors. If high sensitivity and/or real-time imaging capability were not required, photographic film would ordinarily be preferred because of its high spatial resolution. The specific photographic film could be chosen from among the many commercially available x- and γ-ray films.



The γ-Ray and/or X-Ray Telescope would contain reflecting, grazing-incidence reflectors. One pair of reflectors is shown here, but multiple coaxial nested pairs could be used to form images simultaneously at multiple γ-ray or hard-x-ray photon energies or to enhance the collection area at a single photon energy.

This work was done by Richard B. Hoover of **Marshall Space Flight Center**. *For further information, Circle 67 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 16]. Refer to MFS-28482.

Microscope Would Image X and γ Rays

High spatial and moderate spectral resolution would yield new information in several fields of research.

Marshall Space Flight Center, Alabama

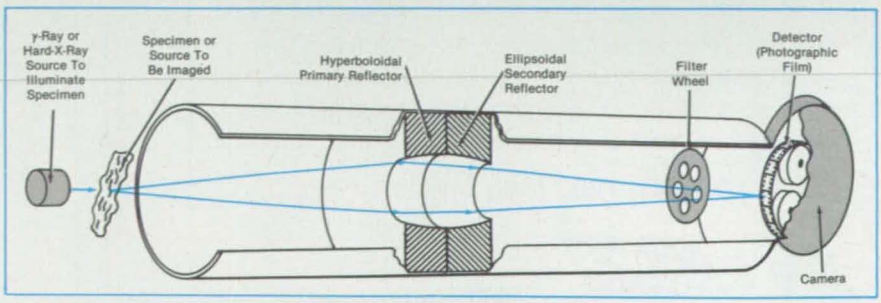
A proposed microscope would form images of sources of radiation or of irradiated specimens at γ-ray (30 to 150 keV), hard-x-ray (3 to 30 keV), or soft-x-ray (0.2 to 3 keV) photon energies. The microscope would collect and focus radiation to produce images with moderate spectral resolution and high spatial resolution. Also, because it would use more of the incident radiation than do conventional pinhole γ-ray and hard-x-ray imaging devices, the microscope would enable the use of smaller, cheaper, better-shielded detectors. This combination of features would provide new information of unprecedented value in several fields of research — for example, in probing the fine structures of pulsed plasmas, investigating minute variations in the structures of material specimens that can be penetrated only by hard-x or γ rays, or in producing maps of distributions of radioisotopes in biological specimens.

The microscope would include two coaxial, aspherical, Bragg-reflecting, grazing-incidence reflectors. The principles of its design and operation would be essentially the same as those of the telescope described in the preceding article, "Telescope Would Image X and γ Rays" (MFS-28482). As in visible-light imaging systems, the difference between the telescope and the microscope would lie mainly in the shapes and positions of the optical surfaces. In the microscope, the primary reflector would be a hyperboloid, while the secondary reflector would be an ellipsoid.

The microscope would have to be either operable in a vacuum system or constructed to enclose a vacuum for efficient, nonscattering transmission of the x and γ rays. The source or specimen to be imaged would be placed at the object plane of the grazing-incidence reflectors in the vacuum. A specimen could be mounted on a translation stage for scanning.

This work was done by Richard B. Hoover of **Marshall Space Flight Center**. *For further information, Circle 66 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 16].Refer to MFS-28484.



The γ-Ray and/or X-Ray Microscope would contain Bragg-reflecting, grazing-incidence reflectors, a filter wheel, and a detector like those of the telescope in the preceding article. As in the case of the telescope, multiple nested coaxial pairs of reflectors (not shown here) could be used to form images simultaneously at multiple wavelengths.

Two-Dimensional Acousto-Optical Spectrum Analyzer

Spectral resolution is extended to about 10^5 channels.

NASA's Jet Propulsion Laboratory, Pasadena, California

A state-of-the-art two-dimensional acousto-optical spectrum analyzer processes an input radio-frequency signal in real time into components in any number of spectral channels up to about 10^5. The best prior two-dimensional acousto-optical spectrum analyzer was limited to about 15,000 spectral channels.

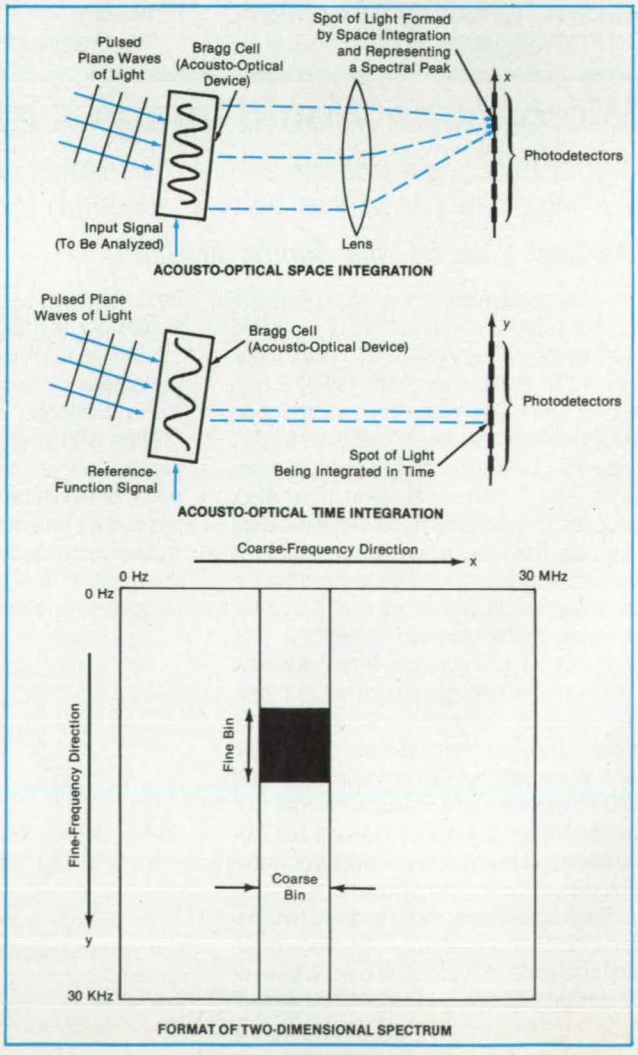
Figure 1 illustrates the general principle of two-dimensional acousto-optical spectrum analysis, in which the coarse spectral resolution is provided by "space-integration" analysis in the x dimension and the fine resolution is provided within each coarse resolution cell by "time-integration" analysis along the y (orthogonal to x) direction. The input radio-frequency signal to be analyzed is launched via a transducer into an acousto-optical device along the x axis. The acousto-optical device thereby becomes a Bragg cell. Pulsed plane waves of light from a laser are aimed at the Bragg cell, which spatially modulates the phases of the plane waves and diffracts the waves according to the pattern of the acoustic signal.

The diffracted light passes through a lens, which forms the spatial Fourier transform of the spatial phase modulation onto photodetectors arrayed along the x direction. The distance of each detector along the x direction from the optical axis or other reference line is proportional to the frequency of a component of the signal being analyzed. The coarse frequency resolution and the useful number of detectors along the x direction depend on the time-bandwidth product of the Bragg cell. In practice, the frequency resolution of this "space-integration" technique is typically of the order of tens of kilohertz.

Continuous laser light could be used in the space-integration technique, but the laser is pulsed to introduce a temporal phase factor into the signal detected in each coarse-resolution channel. The frequency of each such factor is the frequency of the corresponding spectral component of the input signal aliased by the pulse-repetition frequency of the laser. If the pulse-repetition frequency is chosen to be twice the coarse frequency resolution, then the frequency of this temporal phase factor specifies the exact frequency of the spectral component within the given coarse frequency channel.

With this choice, the time-integration technique can be used to segment each coarse frequency channel into fine frequency channels. A signal composed of reference functions is launched into a second Bragg cell along the y direction. A train of diffracted, spatially phase modulated, light beams emerges from the Bragg cell and is imaged onto detectors arrayed along the y direction in the same plane with the space-integrating detectors. The reference functions are chosen such that they form a sampled, temporal, linearly distributed local oscillator along the y direction. The product of each reference-

Figure 1. **Acousto-Optical Integrations in Space and Time** produce the coarse and fine resolutions, respectively, of the spectrum of the input signal.



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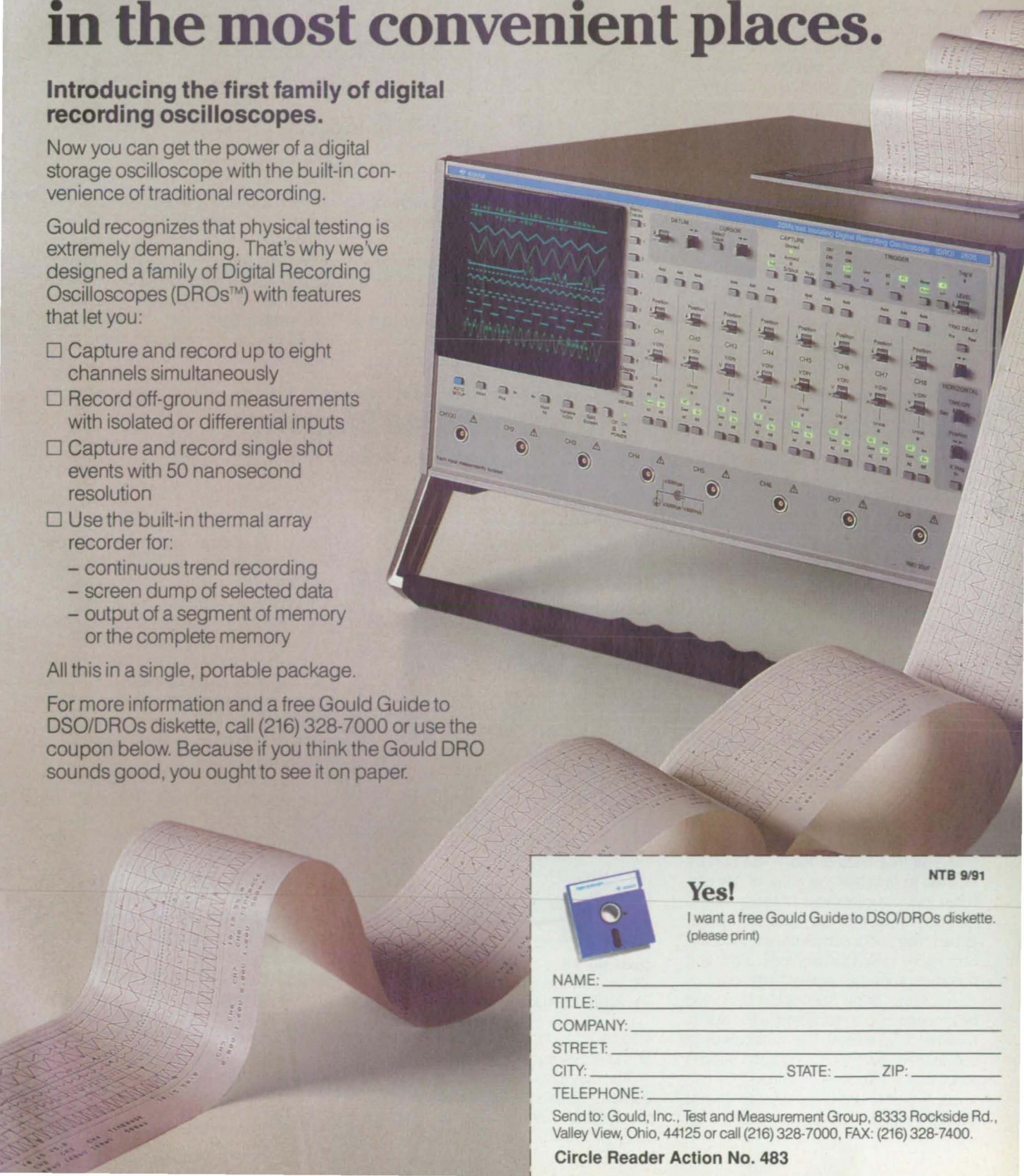

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Circle Reader Action No. 483

function line with the space-integrated spectral peaks is then formed on a two-dimensional (*x* and *y*) array of photodetectors that implements the *x* and *y* arrays mentioned separately above. The array then forms the sum (in effect, the integral over time) of these products over a sequence of reference functions. After this, the intensity within each coarse frequency-resolution channel is no longer uniform along the *y* direction, but time-integrated peaks appear at the locations along the *y* direction where the aliased component frequencies of the signal match the sampled temporal frequency of the distributed local oscillator. The location of the time-integrated spectral peaks along each coarse frequency ridge is thus proportional to the relative fine frequencies of the spectral components thus represented. The width of each time-integrated peak, which is inversely proportional to the number of the reference-function lines over which the time integration is taken, determines the fine frequency resolution of the system.

Figure 2 illustrates the preferred, separate-optical-path method for combining the space- and time-integration functions into a single apparatus (an alternative common-path method entails additional technical difficulties and complications). In this method, the input-signal and reference-function Bragg cells are in two different arms of a Mach–Zehnder interferometer, and the amplitudes of the space- and time-integrated beams are added in a beam splitter before the beams are projected onto the array of charge-coupled devices. The products of the amplitudes are formed on the charge-coupled devices by square-law detection.

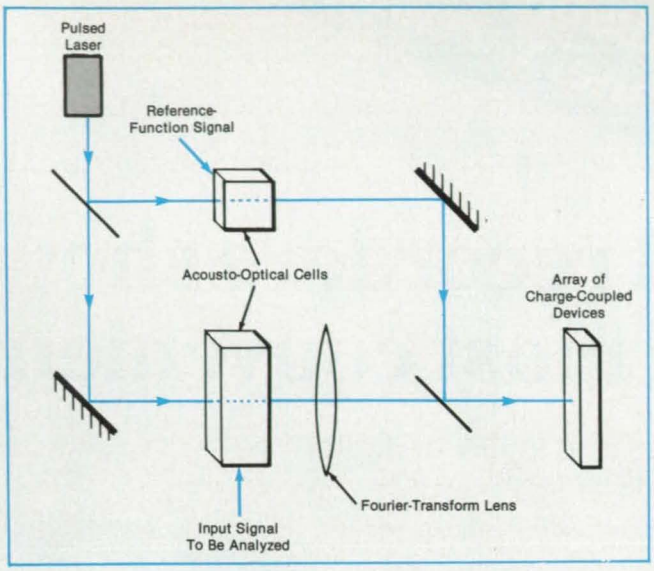


Figure 2. **Space and Time Integrations** are combined by placing the two acousto-optical cells in different arms of a Mach-Zehnder interferometer.

This work was done by Homayoon Ansari and James R. Lesh of Caltech and Brian Metscher of the University of California at Irvine for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 60 on the TSP Request Card.*
NPO-18092

Collectors of Airborne and Spaceborne Particles

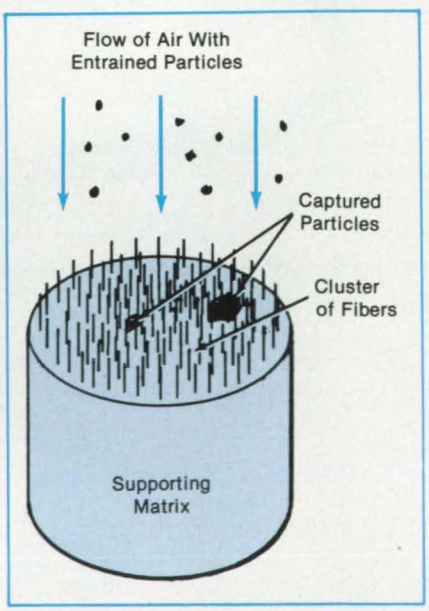
Simple units go directly into optical, electron, or x-ray analysis equipment.

NASA's Jet Propulsion Laboratory, Pasadena, California

Brushlike collectors capture samples of dust and other particles in space vacuum or air for optical, scanning-electron-microscope, and/or x-ray analysis. The collectors gently decelerate the particles without damaging them, minimizing the tendency of some particles to rebound. Depending on the design of a specific collector of this type, it can capture particles ranging upward in size from fractions of a micrometer to a few micrometers.

A collector of this type resembles a stubby, round brush. It consists of an array of fibers embedded in a matrix. In a typical application, the collector would be oriented with the fibers parallel to the direction of the impinging particles (see figure). The free ends of the fibers can be tapered to facilitate the entry of the particles into the interstices of the array. As particles arrive, they are accepted and retained. The fibers can be clustered loosely or tightly to suit the expected sizes and rebound properties of the particles.

A collector of this type can be fabricated by embedding parallel fibers in the matrix material, then etching the matrix away to the desired depth with an oxygen plasma to expose the ends of the fibers, leaving enough of the matrix material to form a supporting base. The oxygen plasma can also be used to thin and taper the ends of the fibers as necessary.



Particles Flow Into a Brushlike Array of fibers with the airstream. The fibers trap particles for subsequent analysis.

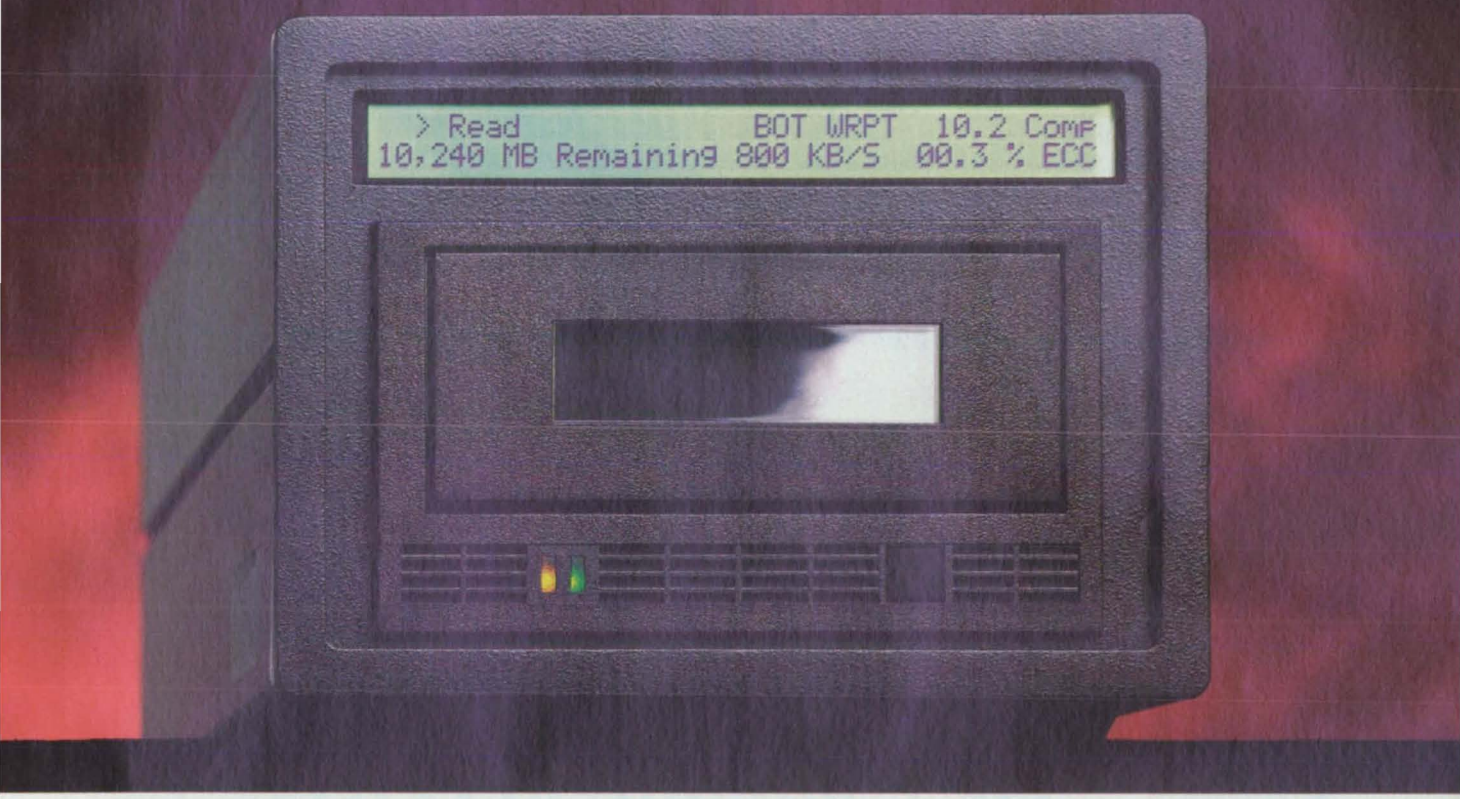
After samples have been captured, the collector serves as a holder for analyzing them. Viewed on end, the fibers appear black and thus provide a contrasting background for microscopic inspection. The known sizes and spacing of the fibers provide a reference scale for determining the sizes of the captured particles. A reference grid can also be etched into the array.

The fibers can be made of carbon, a low-atomic-number material. This improves contrast in scanning electron microscopy (by minimizing backscatter and secondary electrons) and in x-ray analysis (by minimizing x-ray background). The fibers are electrically conductive, and it should not be necessary to apply conductive coats to the captured particles. The fibers are also good thermal conductors and should readily dissipate heat generated by impacts of particles.

Unlike collectors of other types, the carbon-fiber units are not ordinarily coated with sticky materials, which may not endure well under some collection conditions. Furthermore, particles in fiber collector are fixed and do not sink below the surface as they do in a viscous adhesive.

This work was done by Robert E. Frazer of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 58 on the TSP Request Card.*
NPO-18183

NOW THAT 10GB FITS ON AN 8MM TAPE, WHAT ARE YOU WAITING FOR?



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Circle Reader Action No. 411

Algorithm Computes Hypersonic Flow of Air

Nonequilibrium thermochemical effects are taken into account.

Ames Research Center, Moffett Field, California

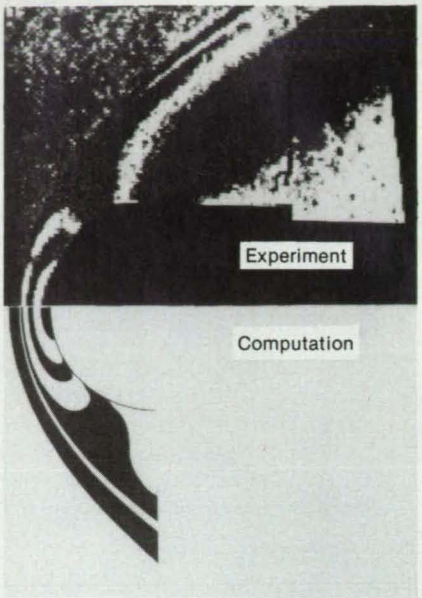
An algorithm simulates the three-dimensional hypersonic flow of air or another mixture of gases around a blunt body. It accounts for nonequilibrium thermochemical effects via a two-temperature mathematical model of molecular excitations and equations for finite-rate chemical reactions. These equations are fully coupled to the fluid dynamical equations.

The mathematical derivation of the algorithm begins, as is customary, with the Navier–Stokes equations for the flow of a viscous, incompressible fluid. These equations are put in conservation-law form, then transformed into generalized coordinates that conform to the body at its surface. The resulting intermediate set of equations represent the conservation of the masses of the various chemical species, the conservation of total mass, the conservation of momentum, the total thermochemical energy density, and the molecular-vibrational component of the thermochemical energy density. The latter two equations represent the two-temperature model, in which the following are assumed: (1) the translational and rotational components of molecular kinetic energy equilibrate immediately, so that they are represented by a single translational temperature, T; and (2) a single vibrational temperature, T_v, characterizes the vibrational state of all polyatomic species present and equals the temperature of all electrons.

The vibrational component of heat conduction is incorporated via a mathematical model for the rate of exchange of energy between the vibrational and translational modes. The diffusion of chemical species is approximated by a combination of binary-diffusion models. Customary models for viscosity and the translational/rotational component of heat conduction are also included. The finite-rate equations represent the following chemical reactions:

$$N_2 + M \rightleftharpoons 2N + M$$
$$O_2 + M \rightleftharpoons 2O + M$$
$$NO + M \rightleftharpoons O + N + M$$
$$NO + O \rightleftharpoons N + O_2$$
$$O + N_2 \rightleftharpoons N + NO$$
$$N + O \rightleftharpoons NO^+ + e^-$$

where M can be any of the other species shown. The algorithm incorporates assumptions about the dependencies of the forward and reverse reactions upon T and T_v. The finite-rate equations for these reactions are solved simultaneously with the global con-



These Interferograms show the density fringes in a flow of dissociating nitrogen across a circular cylinder at a speed of 5.59 km/s. The upper fringe pattern was observed in an experiment. The lower fringe pattern is computed from a flow simulated by the algorithm.

servation-law equations. Without some kind of simplifying approximation, the resulting set of equations would be too large to be solvable on any but the most advanced supercomputers. Here, the size of the problem is reduced by use of an underrelaxation computational process that limits the rate at which the gas can be computed to dissociate and ionize and prevents wild swings in mass fractions and temperatures. The gas is computed to relax gradually and stably to its steady-state compositions and temperatures. The simulation is not time-accurate, but it achieves the proper steady state.

The algorithm has been tested by comparison of its predictions with those of other algorithms and with measurements. It has been found to compute hypersonic flows accurately (see figure). The benefits of the explicit formulation are particularly evident where the complexity of the body requires the use of patched coordinate grids.

This work was done by Grant Palmer of **Ames Research Center**. *Further information may be found in AIAA paper 89A-43217, "The Development of an Explicit Thermochemical Nonequilibrium Algorithm and Its Application to Compute Three Dimensional AFE Flowfields."*

Copies may be purchased [prepayment required] from AIAA Technical Information Service Library, 555 West 57th Street, New York, New York 10019, Telephone No. (212) 247-6500.

ARC-12623

Correlating DSC and X-Ray Measurements of Crystallinity

The degree of crystallinity is roughly proportional to the heat of fusion.

NASA's Jet Propulsion Laboratory, Pasadena, California

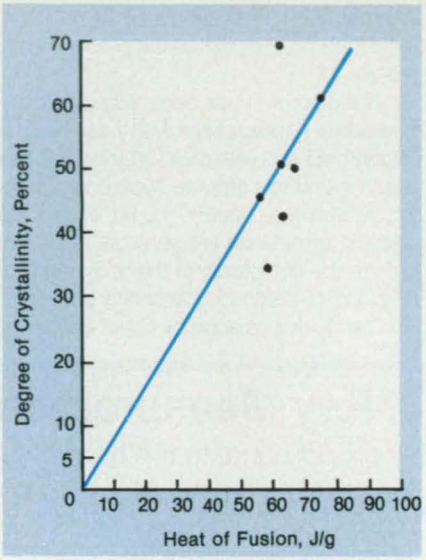
An experiment has demonstrated that there is an approximate linear correlation between the degree of crystallinity of a multiphase polymer (as calculated from x-ray diffraction measurements) and the heat of fusion of the polymer [as calculated from differential scanning calorimetry (DSC) measurements]. This correlation is the basis of a simple new technique for estimating the degree of crystallinity of specimens of the polymer from DSC measurements alone.

The experiment was performed with specimens of polyvinylidene fluoride (PVDF), the microstructure of which consists of interspersed regions of an amorphous phase and two crystalline phases (α and β). PVDF was selected for study because its piezoelectric and pyroelectric properties make it an important material for use in sensors, because its dielectric properties make it an important material for use in capacitors, and because these properties depend on microstructural characteristics and crystallinity.

Each specimen of PVDF was placed in an x-ray diffractometer and rotated (to average out orientational effects) while it was exposed to Cu Kα x-rays. The raw scattering pattern (intensity vs. angle) of each semicrystalline specimen, was recorded, then normalized with respect to the thickness of the specimen and corrected for air scatter, Lorentz polarization, background counts, and incoherent scatter. Next, each specimen was heated on the diffractometer to 168 °C (almost the melting temperature for most specimens) to eliminate the crystalline phases and obtain a scattering pattern for the amorphous phase. After normalization and correction, this pattern was subtracted from the pattern from the semicrystalline condition to obtain the crystalline component of the scattering pattern.

From previous studies, it is known that the integral, over all angles, of the normalized and corrected intensity of scattering from one of the phases is proportional to the amount of that phase in the specimen. In this case, the constants of proportionality were obtained by calculating a linear regression between the integrated α-phase and integrated amorphous-phase intensities of different specimens and a similar regression for the β and amorphous phases. The resulting constants of proportionality were applied to the integrated scattering intensities of the specimens to obtain the fractions of α, β, and amorphous phases. The degree of crystallinity of each specimen was then calculated as the sum of fractions of the α and β phases.

The heat of fusion of each specimen was calculated by integrating to obtain the area under the endothermic portion of its DSC curve. The figure illustrates the correlation between the calculated degree of crystallinity and the calculated heat of fusion. In applying the new technique to other specimens of PVDF or another polymer, one would first calibrate by taking x-ray diffraction and DSC data to obtain a correlation like this one. Thereafter, one would estimate the degree of crystallinity of new specimens from DSC measurements alone by use of the proportionality indicated by this correlation.



The Degrees of Crystallinity of specimens of PVDF (as determined via x-ray diffraction) are correlated with their heats of fusion (as determined via differential scanning calorimetry).

This work was done by Shiao-Ping S. Yen, Lynn E. Lowry, and Clyde P. Bankston of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 8 on the TSP Request Card.*
NPO-17958

Books and Reports

These reports, studies, handbooks are available from NASA as Technical Support Packages (TSP's) when a Request Card number is cited; otherwise they are available from the National Technical Information Service.

Geographical Variations in Measured Lightning Fields

Features of local terrain affect electric fields.

A brief report describes a continuing program of measurements to determine variations, caused by the local terrain, in the vertical electric fields radiated by distant lightning. The lightning electromagnetic field can be increased or decreased with respect to a nominal value, depending on the slope of the local terrain, the extent of local vegetation, and the distances, sizes, and shapes of nearby structures.

The study involves comparisons of measurements of the same lightning strokes taken at different sites. Each site is equipped with, among other things, a flat-plate antenna — essentially, a large parallel-plate capacitor that responds to frequencies up to a few MHz. The antenna at each site is mounted on the ground because in that position its gain is well defined and is simply proportional to its area.

To obtain meaningful comparisons, it is necessary to take measurements for which the nominal vertical electric fields are equal at the sites being compared. The simplest way to assure this condition is to consider data from only those lightning strokes that occur at distances from the sites much greater than the distances between the sites. The distances and/or locations of the lightning strokes can be determined by an existing lightning-locating network. Alternatively, if the lightning is not detected by the network, then the distances to the nearest clouds capable of producing lightning can be assumed to be the applicable distances and can determined by radar and/or satellite remote sensing.

This work was done by Launa Maier of **Kennedy Space Center**. *To obtain a copy of the report, "Measurement of Electromagnetic Enhancement Due to Site Nonuniformities," Circle 41 on the TSP Request Card. KSC-11449*

Azimuthal Anisotropy in Radar Backscatter From the Ocean

Minima are offset from the nominal crosswind directions.

A report describes an experimental and theoretical study of the azimuthal anisotropy in radar backscatter from the surface of the ocean. An important objective of this and related studies is to enhance the ability to sense the speed and direction of the surface wind remotely by use of airborne or spaceborne radar.

The essence of this kind of remote sensing is to synthesize knowledge of the relationship between wind and waves with knowledge of the radar backscattering properties of waves and thereby obtain a technique to infer wind data from radar backscattering data. Often, researchers in this field mathematically model the backscattering cross section by a simple Fourier series; e.g., $\theta_0 = A_0 + A_1 \cos(\theta) + A_2 \cos(2\theta)$, where θ is the azimuthal angle (that is, the ground-track angle) between the radar beam and the wind, and A_0, A_1, and A_2 are coefficients that depend on the speed of the wind, the angle of incidence of the radar beam, and the polarization of the radar beam.

In at least partial agreement with experimental data, this and similar models show a maximum cross section in the upwind direction ($\theta = 0°$), another maximum in the downwind direction ($\theta = 180°$), and minimums near the crosswind directions ($\theta \approx 90°$ or 270°). A_1 and A_2 characterize the up/down-wind anisotropy and the depth of the crosswind anisotropy, respectively. The offset between the directions of each minimum and the nearby crosswind direction increases as A_1/A_2 increases.

In the experimental part of this study, the surface of the ocean was scanned azimuthally by an airborne radar at a frequency of 14.6 GHz. Backscattering cross sections in horizontal and vertical polarizations were measured as functions of θ at various angles of incidence. The backscattering data were initially fitted with a simple Fourier series to obtain rough estimates of the azimuthal locations of the extrema of σ_0. Data within 45° of these estimated locations were then fitted with second-order polynomials, and from these polynomial fits new locations of the extrema were determined. This process was repeated five times to refine the estimate for each extremum.

To provide a physical basis for analysis of the locations of the extrema, the radar-backscattering properties of ocean waves were computed via a two-scale mathematical model, in which the height of the surface of the ocean is divided into a large-scale and a small-scale component, the scattering from the large-scale component is quasi-specular, and the scattering from the small-scale component is more like Bragg scattering. In this case, the small-scale component dominated.

For horizontal polarization, the minimums in the experimental cross sections were found to be significantly offset from the crosswind directions towards the downwind direction. These offsets were substantially smaller for vertical polarization. The offsets predicted by the two-scale model for horizontal and vertical polarizations were found to agree, at least qualitatively, with the experimental offsets.

This work was done by F. K. Li, G. Neumann, S. J. Shaffer, and S. L. Durden of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Studies of the Location of Azimuth Modulation Minima for Ku-Band Ocean Radar Backscatter," Circle 1 on the TSP Request Card.*
NPO-17422

Radar Backscatter From the Ocean at Low Windspeeds

Radar scatterometry can be used to sense winds as slow as 2 m/s.

A report describes an experimental study of radar backscattering from ocean waves generated by winds of 2 to 4 m/s. This study is part of a continuing effort to develop radar scatterometry into a technique for the remote sensing of ocean-surface winds. In this case, the emphasis is upon backscattering at windspeeds previously thought to be at or below the lower limit of scatterometric detectability.

In the experiments, an airborne radar at a frequency of 14.6 GHz was used to make azimuthal scans of the surface of the ocean at angles of incidence from 20° to 30°. Backscattering cross sections in horizontal and vertical polarizations were measured during these scans. Simultaneously, winds near the surface, air and water temperatures, and humidities were measured by recording instruments mounted on buoys in the scanned area.

The data accumulated from these measurements were analyzed and compared with the predictions of mathematical models in which scattering cross sections are represented variously as functions of the azimuthal angle between the ground track of the radar beam and of the wind, the angle of incidence of the radar beam, the radar polarization, the speed of the wind, and/or other parameters. Particular attention was paid to two models: a power-law model, called "SASS-1," which was devised for the analysis of data from the SEASAT scatterometer; a similar model called the Wentz model; and the Donelan and Pierson (D/P) model, which predicts that backscatter cross sections fall off so precipitously as speeds decrease below 2 to 3 m/s that in this speed range scatterometry is probably useless for the measurement of winds.

This analysis showed that the backscattering cross section in the horizontal polarization decreases more steeply with a decrease in speed than it is predicted to do by the SASS-1 and Wentz models but much less steeply than predicted by the D/P model. In the vertical polarization, the corresponding data were found to agree more closely with the SASS-1 model, and the rate of falloff with decreasing speed was again found to be much less than in the D/P model. It was found that the ratio between the backscattering cross sections of the upwind and crosswind azimuths was greater than predicted by the models. Overall, it was concluded that because the cross sections do not fall off as precipitously as they do in the relatively pessimistic D/P model, radar scatterometry remains a viable technique for the measurement of ocean-surface winds at speeds down to 3 (or possibly as low as 2) m/s and angles of incidence up to 30°. Further experimentation will be needed to refine the mathematical model used to infer wind data from scatterometric data.

This work was done by Fuk K. Li and Gregory Neumann of Caltech and Robert A. Weller of Woods Hole Oceanographic Institution for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Observation of Ocean Ku-Band Radar Cross Section at Low Wind Speed During FASINEX," Circle 165 on the TSP Request Card.*
NPO-18036

Materials

Hardware, Techniques, and Processes

Superfiber for Strong, Light Fabrics

Polyolefin fiber resists chemicals and abrasion.

Lyndon B. Johnson Space Center, Houston, Texas

A new ultrahigh-molecular-weight fiber offers major advantages as a fabric for space suits, diving suits, sporting goods, sails, and ultralight aircraft. The polyolefin fiber has an extremely high modulus of elasticity, low elongation, high specific strength, low specific gravity, resistance to chemicals, low moisture absorption, and high resistance to damage by flexure and abrasion.

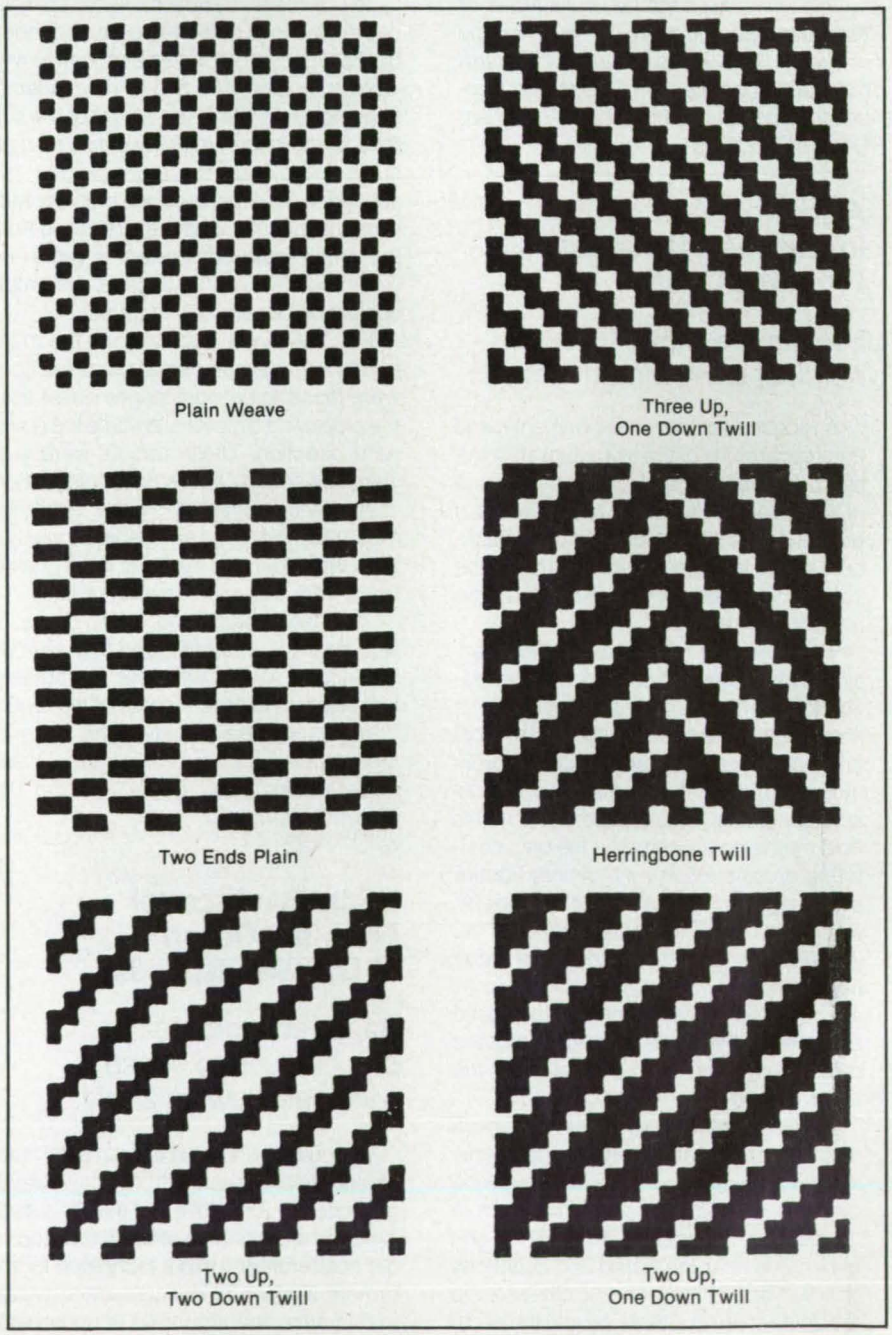
The fiber is available in a variety of weave patterns, including plain, herringbone and other twill, and basket-weave patterns (see figure). Besides plain fabric, the fiber is available as plain braided cord, braided cord woven into link nets, flat woven tape, and webbing. Its high strength per unit weight — higher than that of any other polymeric fiber — allows space suits, diving suits, or balloons to be pressurized to 8.3 lb/in.^{2} (57 kPa). Its light weight gives wearers greater mobility.

The new fiber consists of elongated, highly aligned, highly crystalline polyethylene molecules. This structure not only results in a high strength-to-weight ratio but also gives high resistance to tearing and ripping.

In comparison with Kevlar (or equivalent) aromatic polyamid fiber — until now, a material of choice in high-strength applications — the new material can be made into 40 percent more fiber per pound and has 7 to 20 times the resistance to abrasion. Moreover, because its coefficient of friction is low, little heat is generated during abrasion.

Chemically, the new material is nearly inert. It is hardly affected by either alkaline or acidic compounds. When exposed to a broad range of chemicals for a period of 6 months, the fibers retained all their original strength in almost every instance. In addition, because water molecules cannot attach themselves to the polymer chains, the material absorbs little moisture and remains lightweight under wet or humid conditions.

This work was done by Frederic S. Dawn and Joseph J. Kosmo of **Johnson Space Center**. *For further information, Circle 140 on the TSP Request Card.* *MSC-21659*



Fibers Can Be Woven in many patterns, a few of which appear here. The fabrics offer a combination of desirable properties not found in nylon, polyester, or aramid fabrics.

HIGH-NICKEL ALLOYS THAT CAN TAKE THE HEAT...AND MORE.

Principal required characteristics \ Alloys	INCONEL alloy 600	INCONEL alloy 601	INCONEL alloy 617	INCONEL alloy 690	INCONEL alloy 718*	INCONEL alloy X-750*	INCONEL alloy MA 754	INCOLOY alloy 800	INCOLOY alloy 800HT	INCOLOY alloy 802	INCOLOY alloy 909*	INCOLOY alloy MA 956	INCO alloy HX	INCO alloy 330
High-temperature strength	Good	Better	Best	Good	Best	Best	Best	Good	Better	Better	Best	Best	Better	Good
Oxidation resistance	Better	Best	Best	Better	Better	Better	Best	Good	Good	Good		Best	Best	Good
Sulfidation resistance	Good	Best	Best	Better		Good	Good	Best	Best	Best		Best	Better	Better
Carburization resistance	Best	Better	Best	Better	Better	Best	Best	Good	Good	Better		Best	Good	Good
Nitriding resistance	Best	Better	Better					Good	Good	Good			Better	Good
Carbonitriding resistance	Best	Better	Better					Good	Good				Better	Good
Resistance to molten heat-treating salts	Best	Better	Best					Good	Good				Better	Good

This table should be used as a guide only. Final selection should be made after a complete technical review of temperatures and atmospheres involved in your particular operation.

*Strengthening by precipitation hardening limits usual service to intermediate temperatures.

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INCO ALLOYS INTERNATIONAL

Circle Reader Action No. 569

LaRC-RP41: a Tough, High-Performance Composite Matrix

A new polymer exhibits increased toughness and resistance to microcracking.

Langley Research Center, Hampton, Virginia

Recently, work has been done on the interpenetrating-polyimide-network (IPN) approach to developing tough, microcracking-resistant, high-temperature matrix resins for use in aircraft and aerospace structural components. One such polymer was designated LaRC-RP40. This simultaneous semi-IPN was prepared from easy-to-process, but brittle, cross-linking PMR-15® and tough, but difficult-to-process, linear NR-150B2®. Both of these raw materials are commercially available. The combination exhibited significant improvements in toughness, resistance to microcracking, and glass-transition temperature over those of PMR-15. These results encouraged further exploration of this approach for the development of a wider range of polymers of basic technological and economic interest.

In an experiment, cross-linking PMR-15 and linear LaRC-TPI were combined to provide a new, sequential semi-2-IPN designated as LaRC-RP41. LaRC-RP41 was synthesized from PMR-15 imide prepolymer undergoing cross-linking in the immediate presence of LaRC-TPI polyamic acid, which was also undergoing simultaneous imidization and linear chain extension. This synthesis is shown in the figure. LaRC-RP41 was prepared and tested both in neat form and as the matrix of a composite reinforced with graphite fibers. Neat and composite specimens of PMR-15 and LaRC-TPI were similarly prepared and tested.

In comparison with PMR-15, LaRC-RP41 showed significantly improved toughness and resistance to microcracking. However, the glass-transition temperature and mechanical performance at elevated temperature were substantially lower than those of PMR-15. The LaRC-TPI phase acts as an effective plasticizer, rather than as a reinforcement, and it controls the toughness, microcracking behavior, and elevated-temperature mechanical performance of LaRC-RP41.

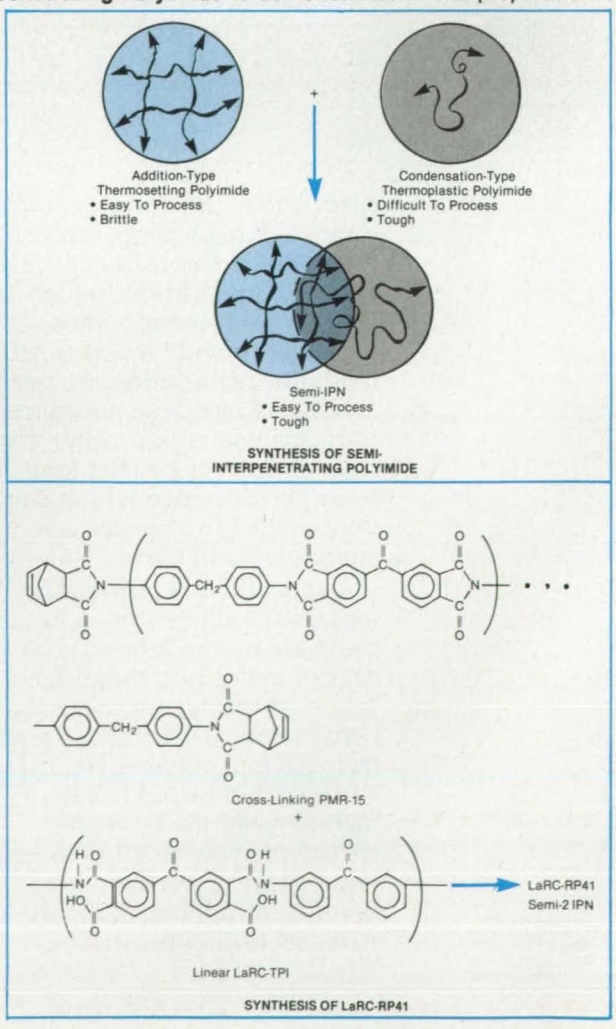
LaRC-RP41 exhibited apparent two-phase microstructure. The stability of the phases was affected by time and temperature in service as well as by the presence of graphite fibers. Thus, any efforts based on the exploitation of relationships between properties and microstructure to develop high-performance semi-IPN's must take into account the stability of the phases of a semi-IPN.

LaRC-RP41 has potential as a high-temperature matrix resin, adhesive, and molding resin. Applications could include automobiles, electronics, aircraft, and aerospace structures.

This work was done by Ruth H. Pater, Norman J. Johnston, Ricky E. Smith, and John J. Snoha of **Langley Research Center**, *Carol R. Gautreaux of Analytical Services and Materials, Inc., and Rakasi M. Reddy of Old Dominion University. For further information, Circle 158 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center [see page 16]. Refer to LAR-14338.

Synthesis of Semi-Interpenetrating Polyimide is demonstrated in the preparation of LaRC-RP41.



Controlled Temperature Gradient Improves Freezing Alloy

Better microstructure increases fatigue life.

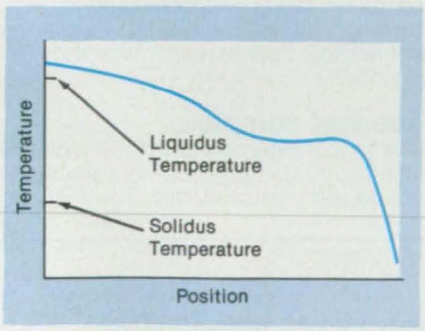
Marshall Space Flight Center, Alabama

A controlled gradient of temperature in the advancing zone of solidification increases the fatigue life of a directionally solidified nickel-base superalloy. The improved solidification process eliminates, reduces, or controls the microstructure of deleterious brittle phases, including carbides and γ/γ' eutectic. The improved process also reduces microsegregation and makes discrete carbides (if present) become fine and blocky.

Unlike a pure metal, an alloy melts and freezes over a range of temperatures rather than at a single temperature: it is completely molten above the liquidus temperature, completely frozen below the solidus temperature, and consists of liquid (of one composition) between dendritic solid regions (of another composition) at intermediate temperatures. The gradient of temperature through the advancing liquid/solid zone in a directionally solidifying specimen of alloy affects the final, solidified microstructure by influencing the width of the solid/liquid zone and the time spent solidifying.

In the improved process, the spatial and temporal distribution of temperature between the advancing liquidus and solidus surfaces is tailored as follows: Below the liquidus temperature, the gradient of temperature is kept small and caused to make a transition to a temperature plateau in the liquid/solid zone. After the plateau, the gradient of temperature is large and remains so during the remainder of solidification (see figure).

The fatigue life of MAR-M246(Hf) alloy solidified in the improved process is increased by a factor of 10 to 100 over that of the same alloy produced by more-conventional high-temperature-gradient directional solidification. The use of controlled temperature gradients is also expected to improve the properties of other alloys, of both directionally-solidified polycrystalline and single-crystal forms.



When the **Temperature as a Function of Position** along a directionally solidifying specimen of alloy looks something like this, the resulting solidified microstructure favors increased fatigue life. The combination of different thermal gradients that yields the best mechanical properties must be determined by experimental studies.

This work was done by Deborah Schmidt, Wendy S. Alter, and William D. Hamilton of **Marshall Space Flight Center**. *For further information, Circle 53 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 16]. Refer to MFS-28314.

Manufacturing Ethyl Acetate From Fermentation Ethanol

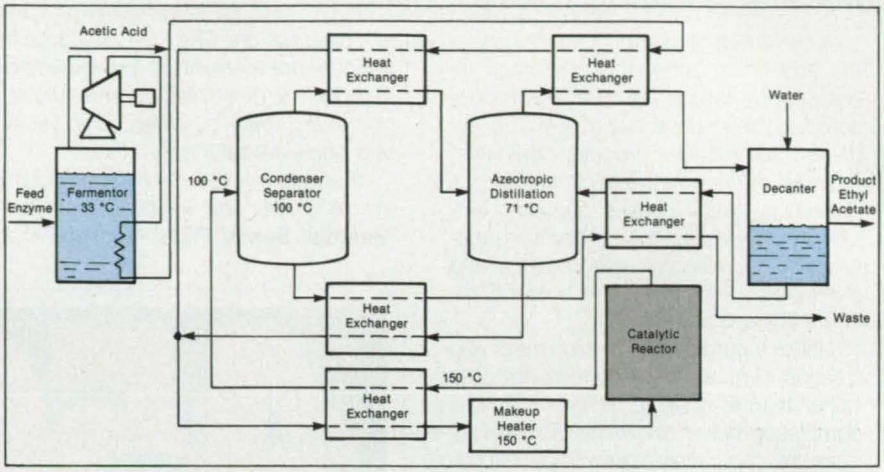
A conceptual process would use a dilute product of fermentation instead of concentrated ethanol.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed process would synthesize ethyl acetate from low-concentration (4 to 6 weight percent) fermentation ethanol. Ethyl acetate, a widely used solvent, is currently made from costly distilled ethanol (93 weight percent). The new process would consume less energy — 1,600 to 2,000 Btu per pound (3.7 to 4.7 MJ per kilogram) versus more than 3,000 Btu per pound (7 MJ per kilogram) of ethyl acetate for the current process.

In the proposed new process, a vacuum would continuously remove a mixture of ethanol and water vapors from a fermentor maintained at a temperature of 33 °C and atmospheric pressure (see figure). Acetic acid would be added to the ethanol and water vapor, and the combined stream would be fed to a catalytic reactor, where ethyl acetate would be synthesized. The reaction would proceed in the vapor phase at a temperature of 150 °C and a pressure of 1 atm (0.1 MPa) with zirconium oxide or silica gel as catalyst.

The gaseous product from the reactor would be cooled to 100 °C to remove excess water and unconverted acetic acid.



Low-Concentration Ethanol, extracted by vacuum from a fermentation tank, and acetic acid would constitute the feedstock for a catalytic reaction. The product of the reaction would go through steps that would increase the ethyl acetate content to 93 percent by weight. To conserve energy, heat exchangers would recycle waste heat to preheat the process streams at various points.

Azeotropic distillation at 71 °C would produce a solution of 83 percent ethyl acetate, 9 percent ethanol, and 8 percent water by weight. This distillation would recover much of the unconverted ethanol, which would be recycled into the ethanol/water-vapor/acetic acid stream going to the catalytic reactor. A final decantation would yield a commercial grade product composed of 93 percent ethyl acetate, 5 percent ethanol, and 2 percent water by weight.

Two alternative schemes for using fer-

mentation ethanol directly were considered; calculations showed that both would be less energy-efficient than the proposed vacuum-extraction scheme would be. In one of these schemes, carbon dioxide stripping would be used to remove ethanol from the fermentor; this scheme would consume over 2,200 Btu per pound (5.1 MJ per kilogram) of ethyl acetate. In the other scheme, ethanol would be distilled directly from the product of the fermentor and used to synthesize ethyl acetate; this scheme would consume about 2,800 Btu per pound (6.5 MJ per kilogram) of ethyl acetate.

This work was done by Naresh K. Rohatgi and John D. Ingham of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 4 on the TSP Request Card.*
NPO-17923

New Polyimide Has Many Uses

Low-toxicity and low-mutagenicity monomer is the key to a new high-performance polyimide.

Langley Research Center, Hampton, Virginia

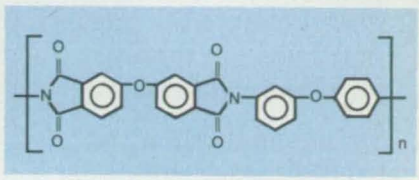
High-performance polyimide adhesives are used in the aerospace industry; for example, in joining metals to metals or metals to composite structures. In addition, they are rapidly being put to new uses as matrix resins for composites, molding powders, and films. These materials display a number of high-performance characteristics; for example, resistance to high temperatures and to solvents, improved flow for better wetting and bonding, high modulus of elasticity, and resistance to chemicals and hot water. One area of application is the manufacture of lighter and stronger aircraft and spacecraft structures.

LaRC-TPI is a thermoplastic polyimide well known as a high-performance material. Its structure is derived from 3,3′-, 4,4′-benzophenonetetracarboxylic dianhydride (BTDA) and 3,3′-diaminobenzophenone (3,3′-DABP), and it is prepared in 2-methoxyethyl ether (diglyme). Invented at NASA Langley Research Center, it is now a commercially available product. However, the commercialization of the 3,3′-DABP component of LaRC-TPI has not occurred in the United States because it has been shown to be a mutagen. Therefore, only experimental samples of this chemical can be purchased in this country for research purposes.

A new polyimide, identified as LaRC-IA, exhibits flow and adhesive properties similar to those of LaRC-TPI. This novel polymer is prepared from the low-toxicity, commercial diamine 3,4′-oxydianiline (3,4′-ODA) and the commercially available dianhydride 4,4′-oxydiphthalic anhydride (ODPA) in 2-methoxyethyl ether (diglyme). This polymer (see figure) has been prepared in both ultra-high-molecular-weight (exact stoichiometry of diamine and dianhydride) form and in a controlled-molecular-weight form, which has a 2.5-percent offset in stoichiometry (excess diamine) with a 5.0-percent level of phthalic anhydride as an end cap.

The controlled-molecular-weight form allows for greatly improved processing of the polymer for moldings, adhesive bonding, and the fabrication of composites. The version that has the higher molecular weight affords tougher films and coatings. The glass-transition temperature of the polymer, as determined by differential scanning calorimetry, is between 230 and 240 °C. The overall polymer structure with oxygen flexibilizing linkages in both the dianhydride and the diamine, as well as a meta linkage in the diamine, affords adequate flow properties for making this polymer useful as a molding powder, adhesive, and matrix resin for composite materials.

Adhesives, composite matrix resins, neat resin moldings, and coating films made of the new polymer have been found to exhibit properties identical or superior to those of commercially available polyimides. The end-capped version of ODPA/3,4′-ODA has been used to prepare graphite-reinforced composites because this version exhibits melt flow superior to that of the non-end-capped version. This higher level of melt flow is important in making large, composite objects that have complicated shapes. Potential applications for this polyimide are wide ranging. With and without end capping, it can be employed to prepare unfilled moldings, coatings and free films, adhesive tape, adhesively bonded substrates, prepregs, and composites.



LaRC-IA is a thermoplastic polyimide made from 3-4′-oxydianiline and 4,4′-oxydiphthalic anhydride. It has good processing characteristics, low toxicity, and no mutagenicity.

This work was done by Terry L. St. Clair, Donald J. Progar, Janice Y. Smith, and

Ricky E. Smith of **Langley Research Center**. *For further information, Circle 123 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center [see page 16]. Refer to LAR-14163.

Copper-Exchanged Zeolite L Traps Oxygen

Simple chemical treatments make this material an efficient and capacious trap for oxygen.

NASA's Jet Propulsion Laboratory, Pasadena, California

A brief series of simple chemical treatments has been found to enhance the ability of zeolite L (Linde LZ-Y72) to remove oxygen from a mixture of gases. The treatments were investigated in the effort to develop a material that could reduce contamination by oxygen in gases at high temperatures. Heretofore, few materials could function at high temperatures with adequate capacity for oxygen.

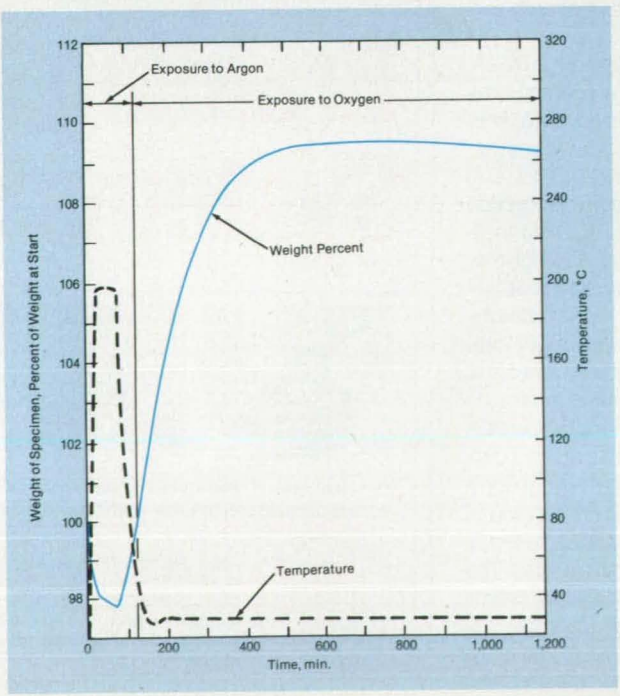
Zeolite L is thermally stable up to 700 °C and has a high specific surface area (~400 m^2/g), which provides its high capacity for adsorption of gases. To increase its ability to adsorb oxygen selectively, copper is added by ion exchange, and the copper-exchanged zeolite is reduced with hydrogen. As a result, copper is dispersed atomically on the inner surfaces of the zeolite, making it highly reactive to oxygen, even at room temperature. The reactivity to oxygen is expected to be even greater at higher temperatures. The capacity for oxygen uptake may, however, be smaller at higher temperatures.

In preparation for a test of this concept, fresh zeolite L was crushed and sieved in the size range of 10 to 25 mesh (2 mm to 710 μm). Some of the zeolite was prepared for the copper-exchange treatment by first treating it with 1.0 molar NH_4NO_3 solution, decreasing its sodium content from 1.10 to 0.16 weight percent. Then it was treated with 0.2 molar $Cu(NO_3)_2$ solution, adding copper in the amount of 1.94 weight percent.

Both the copper-exchanged and untreated zeolite were reduced with hydrogen, then tested for oxygen-uptake capacity. The treated zeolite was reduced in a flowing mixture of nitrogen and hydrogen at 180 °C for 8 hours, during which time the concentration of hydrogen was gradually increased from 1 to 30 percent. The reduced, copper-exchanged zeolite was heated under argon at 200 °C for 1 hour, then cooled to room temperature. Next, the argon was replaced by oxygen, and the zeolite gained weight by about 9.5 percent (see figure), attributed to the adsorption of oxygen.

The untreated zeolite was reduced at 200 °C in a mixture of 4 percent hydrogen and 96 percent argon, then placed in contact with oxygen and allowed to cool to room temperature. The total adsorption of oxygen in this case was about 5 weight percent.

This work was done by Pramod K. Sharma and Panchalam K. Seshan of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 152 on the TSP Request Card.* *NPO-17761*



This **Thermogravimetric Plot** shows the gain of weight of the reduced, copper-exchanged zeolite upon exposure to oxygen.

Computer Programs

COSMIC: Transferring NASA Software

COSMIC, NASA's Computer Software Management and Information Center, distributes software developed with NASA funding to industry, other government agencies and academia.

COSMIC's inventory is updated regularly; new programs are reported in *Tech Briefs*. For additional information on any of the programs described here, circle the appropriate TSP number.

If you don't find a program in this issue that meets your needs, call COSMIC directly for a free review of programs in your area of interest. You can also purchase the annual *COSMIC Software Catalog*, containing descriptions and ordering information for available software.

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The University of Georgia, 382 East Broad Street, Athens, Georgia 30602

Computer Programs

These programs may be obtained at a very reasonable cost from COSMIC, a facility sponsored by NASA to make computer programs available to the public. For information on program price, size, and availability, circle the reference number on the TSP and COSMIC Request Card in this issue.

Electronic Systems

Software for Multivariable Frequency-Domain Analysis

Outputs include frequency-response singular-value plots of multivariable transfer matrices.

FREQ (Multivariable Frequency Domain Singular Value Analysis Package) is a software package of subroutines that perform frequency-domain analysis of (1) continuous- or discrete-multivariable linear systems, (2) any continuous system for which one can calculate the transfer matrix at points on the imaginary axis, or (3) any discrete system for which one can calculate the transfer matrix at points on the unit circle. Many approaches in the field of the analysis of, and the synthesis of controllers for, linear, multivariable, time-invariant systems involve loop-shaping procedures. Within these procedures, design parameters are chosen to shape frequency-response singular-value plots of selected transfer matrices. FREQ computes, within one unified framework, many of the most-used multivariable transfer matrices. The matrices are evaluated at frequency-response values selected by the user, and singular values and vectors are computed. FREQ also tabulates maximum and minimum singular values against frequency.

A document that describes FREQ includes an example with data taken from a study in which a fine-pointing attitude-control system was designed for a large, flexible hoop/column space antenna. The control system was designed to exhibit stability robustness with respect to high-frequency, unmodeled components of the dynamics of the antenna, and a prototype version of FREQ was employed to obtain the robustness-barrier-design plots. As other applications of FREQ indicated new users' needs and preferences, FREQ evolved through a sequence of applications in the analysis and design of controls. The current version of FREQ provides a body of tested software that incorporates most of the desired properties and options needed by the practicing engineer.

Four different versions of FREQ are available from COSMIC. The user may choose between single- and double-precision versions and between brief and complete versions. To use the brief versions, the user must have access to the numerical linear-algebra packages LINPACK (real and complex versions) and EISPACK in the same precision as that of the version of FREQ being used. The single-precision brief version is LAR-14119, the single-precision complete version is LAR-14120, the double-precision brief version is LAR-14121, and the double-precision complete version is LAR-14122.

The double-precision version is recommended for such 32-bit computing equipment as a DEC VAX or Sun Microsystems workstation. The brief version offers the economy of less code to compile and store. In addition, if the brief version is installed on a super-computer or minicomputer, the computer may already have a version of LINPACK with the Basic Linear Algebra Subprograms (BLAS) subpackage optimized to its architecture. The use of this version of LINPACK will result in a more efficient package. All four versions of FREQ may be purchased together as a package (COS-10024).

The user gains access to FREQ by writing a program in FORTRAN 77 that makes calls to subroutines in the FREQ package. FREQ is written in ANSI standard FORTRAN 77 (with minimal extensions in the double-precision versions to support the use of the COMPLEX*16 data type) and is intended to be independent of the specific computing equipment (except that some FORTRAN compilers do not support COMPLEX*16). Representative memory requirements (in bytes) on a VAX computer running VMS 5.2 and using VAX FORTRAN 5.1-10 are 59K for single-precision brief, 75K for single-precision complete, 73K for double-precision brief, and 91K for double-precision complete. The amounts stated here for the brief versions do not reflect the size of the required proprietary routines. This program contains copyrighted material and was developed in 1989.

This program was written by Ernest S. Armstrong of **Langley Research Center** *and Daniel P. Giesy of Planning Research Corp. For further information, Circle 157 on the TSP Request Card.*
LAR-14119, LAR-14120, LAR-14121, and LAR-14122

Waveform-Generating Program

A variety of complicated waveforms can be synthesized digitally from simpler component waveforms.

The development of useful signal-processing equipment and software requires a high-quality signal generator that can produce a wide array of accurate test signals. Conventional electronic signal generators, though accurate, are limited in the number, frequency, and amplitude of individual waveforms they can provide. To fill the need for a signal generator that overcomes these traditional limitations, scientists at Rockwell International developed the GENERATE (Digital Generation of Complex Waveforms) computer program as a flexible and reliable software tool for advanced generation of waveforms.

With GENERATE, the user employs standard arithmetic operators (+, −, ×, /, and parentheses) to simulate any combination of eight commonly used basic waveforms at the desired amplitude and frequency. GENERATE creates a data file based on the user's selections from a menu. The menu provides the necessary equations that describe the eight basic waveforms and enables the user to combine them arithmetically. The basic waveforms offered as building blocks are the sine, ramp, exponential, logarithmic, step, clipped sine, square, and sawtooth.

The user controls the parameters of the signal being generated, including the amplitude (infinite range), sample rate (infinite range), number of individual signal chan-

nels (up to 16), duration, and Gaussian noise properties (requires Gaussian-white-noise routines supplied by the user). The file of data thus created appears as digitized sound information, which is compatible as input with related data-analysis software. The digitally simulated waveform is useful in verifying the integrity of new signal-processing software, especially where a known time signal is necessary.

GENERATE also contains a routine for plotting the output waveform data on a terminal with a Tektronics (or equivalent) emulator, providing visual confirmation of the desirability of the waveform.

GENERATE was developed by use of VMS FORTRAN on a DEC VAX 3600 computer. The program occupies approximately 200 KB of memory, but its output files may require considerably more. Memory requirements for the files of waveform data depend on the complexities of the waveforms they represent — e.g., a signal generated over two channels at a sample rate of 10,240 s^{-1} for 60 s would require 2.5 MB (2×10,240×60 words ×2 bytes/word).

This program was written by Charles B. Hopson of Rockwell International Corp. for **Marshall Space Flight Center**. *For further information, Circle 89 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 16]. Refer to MFS-28408.

Physical Sciences

Controlling Laboratory Processes From a Personal Computer

An operator can control processes via natural-language commands.

A computer program provides natural-language process control from an IBM PC or compatible computer. This program sets up a process-control system that can either run without an operator or be run by workers who have limited programming skills.

The complex environment of the typical research laboratory requires flexible process control. Sometimes process-control schedules require frequent changes, even several times per day. These changes may include the addition, deletion, or rearrangement of steps in a process. The program facilitates such changes.

The program includes three smaller programs. Two of them, written in FORTRAN77, record data and control research processes. The third program, written in Pascal, generates the FORTRAN subroutines used by the other two programs to identify the user commands with device-driving routines (device drivers) written by the user. The program also includes a set of input data that allows the user to define the user commands to be executed by the computer.

To set up the system, the operator writes the device-driving routines for all of the controlled devices. Once set up, this system requires only an input file that contains natural-language command lines that tell the system what to do and when to do it. The operator can make up custom commands for the operation of, and the taking of data from, external research equipment, at any time of the day or night, even when the operator is not in attendance.

This process-control software system requires a personal computer operating under MS-DOS with suitable hardware interfaces to all controlled devices. The program requires a FORTRAN77 compiler and device drivers written by the user. This program was developed in 1989 and requires 62K bytes of memory.

This program was written by H. Will and M. A. Mackin of **Lewis Research Center**. *For further information, Circle 133 on the TSP Request Card. LEW-14907*

Mathematics and Information Sciences

System Decommutes and Displays Telemetry Data

The TDPlus system transforms a computer into a telemetry processor.

The TDPlus computer program is a software system for the decommutation of pulse-code-modulation (PCM) telemetry signals. TDPlus provides synchronization, conversion into engineering units, and display of serial bit streams. The TDPlus software system transforms an IBM PC-compatible computer into a PCM-telemetry-decommutation system. PCM is the most common form of modulation used to transmit telemetry from spacecraft, but the data in the PCM stream are multiplexed in time. One of the unique features of the TDPlus system is that it provides a way to look at PCM data for about a tenth of the cost of equivalent decommutators. The software structure is built by use of popup menus and windows that come from an existing commercial library. The use of these functions makes TDPlus very easy to use.

The TDPlus system synchronizes telemetric signals data and enables the conversion of them back into such meaningful forms as voltage, current, pressure, and the like. These data can then be displayed on numerical charts, bar charts, or graphical X–Y displays. The TDPlus system also controls the operation of digital-to-analog converters to ship data to paper strip charts or to parallel digital ports for offloading to other computers.

An engineer typically uses TDPlus as a stand-alone program, setting up and editing TDPlus tables to customize the program for a particular application. This software can be used to process actual data only when the telemetry-data-processing computer has been modified in accordance with specifications contained in *NASA Tech Brief* "TDPlus TM Data Processor" (GSC-13291). The modified computer consists of an IBM PC-compatible computer and four custom boards, built and designed by NASA/Wallops Flight Facility. The computer, together with the TDPlus program is then a full PCM-telemetry-decommutation-and-display system. However, the TDPlus program TDP.EXE can be run on any PC-compatible computer for purposes of editing and demonstration.

Notice: This COSMIC software is only half of the TDPlus package. The hardware-design documentation must be obtained from the Technology Utilization Office at Goddard Space Flight Center.

This program can be executed on any IBM PC-compatible computer operating under MS-DOS or IBM PC-DOS, version 3.2 or 3.3. The program requires a VGA, EGA, CGA or Hercules monochrome video adapter and 640 KB of random-access memory. The program is written in Turbo C and 8088 Assembly language. Compilation of the source code requires Borland Turbo C version 2.0 and IBM or Microsoft MASM version 3.0 or greater, plus two commercial library software packages: Blaise Turbo C Tools Version 6.0 (Blaise Computing, Inc.,) and Science and Engineering Tools for Turbo C 2.0 version 6.0 (Quinn-Curtis). The program was developed in 1989.

IBM PC and PC-DOS are registered trademarks of International Business Machines. MS-DOS is a registered trademark of Microsoft Corporation. Hercules is a registered trademark of Hercules Computer Technology.

This program was written by D. E. Massey and B. Corbin of **Goddard Space Flight Center**. *For further information, Circle 147 on the TSP Request Card.*
GSC-13324

Mechanics

Hardware, Techniques, and Processes

Adaptive Control of Large Vibrating, Rotating Structures

The inherent passivity of structures is exploited to obtain convergence.

NASA's Jet Propulsion Laboratory, Pasadena, California

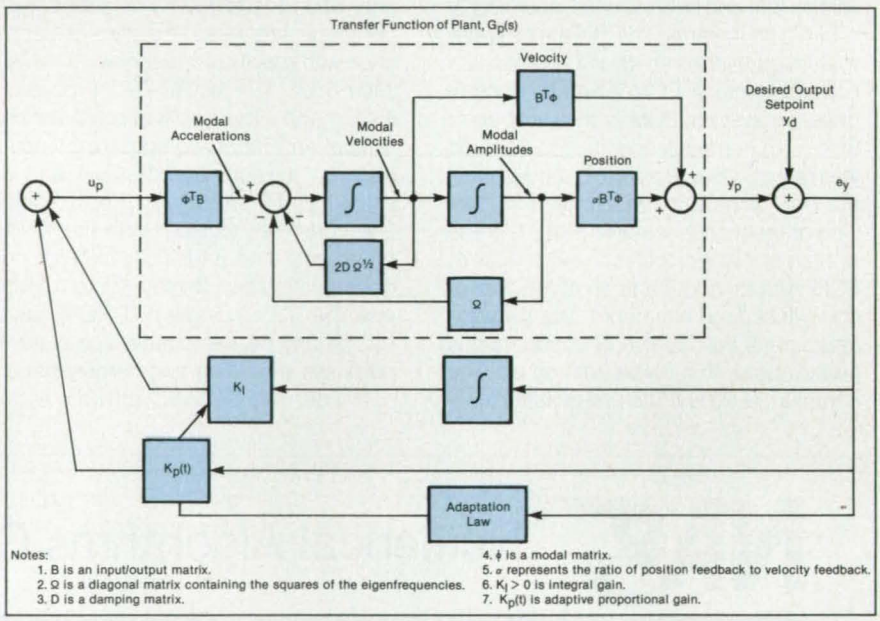
A globally convergent theoretical method provides for the adaptive set-point control of the orientation of, along with suppression of the vibrations of, a large structure. Developed for controlling the attitudes of large, somewhat flexible spacecraft, the method may also be useful in such terrestrial applications as controlling movable bridges or suppressing earthquake vibrations in bridges, buildings, and other large structures.

The method utilizes the inherent passivity properties of the structure to attain a mathematical condition essential to adaptive convergence on the commanded set point. Under this condition, the system is said to be "robustly stabilized against spillover dynamics," meaning that it maintains stability and convergence in the presence of errors in the mathematical model of the dynamics of the structure and actuators.

The new method offers the advantage of avoiding the command-generator-tracker (CGT) condition typically associated with model-following solutions to the same control problem. The tracking condition that replaces the CGT condition is satisfied by the same conditions that assure the strictly positive real (SPR) property of the structure. More specifically, the control architecture in the new method is based on proportional-integral feedback from position and velocity sensors (see figure), and the CGT condition is replaced by the most stringent sufficient condition for global asymptotic stability, which requires the existence of an output feedback matrix, K, such that the closed-loop system is SPR.

An important feature of the new method is that stability conditions are satisfied if the ratio of position feedback to velocity feedback is chosen sufficiently small relative to a quantity that depends on the intrinsic structural damping, modal frequencies, number of actuators, and the controllability of the rigid-body modes relative to the flexible-body modes at the actuator/sensor locations. Such conditions are relatively mild and can always be satisfied by design, making use of coarse ground test data.

The characterization of the closed-loop stability properties is based on a new Lyapunov function. This function, in itself, extends application of many prior techniques based on positivity theory (both adaptive and nonadaptive) to the more-realistic case in which rigid-body modes are present in the dynamics, and, as a consequence, the problem of controlling the attitude is solved simultaneously with, and as an integral part of, the problem of suppressing the vibrations.



The Adaptive Set-Point Control Architecture is Applied to a Flexible Structure that is weightless or otherwise free and that is equipped with collocated torque actuators and position and velocity sensors.

This work was done by David S. Bayard of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 23 on the TSP Request Card.*
NPO-17471

Vaporization Would Cool Primary Battery

Less material would be needed in cooling by vaporization than in cooling by melting.

NASA's Jet Propulsion Laboratory, Pasadena, California

The temperature of a discharging high-power-density primary (i.e., nonrechargeable) battery would be maintained below a specified level by the evaporation of a suitable liquid from a jacket that surrounds the battery, according to a proposal. A pressure-relief valve would regulate the pressure and, thereby, the boiling temperature of the liquid. Because the latent heat of vaporization of a typical material is an

order of magnitude larger than the latent heat of fusion of itself or another material, the mass and volume of liquid needed to produce a given amount of cooling would be much less than the mass and volume of material needed to produce the same amount of cooling by melting. This technique could be used to cool batteries in situations in which engineering constraints on volume, mass, and location prevent the attachment of cooling fins, heat pipes, or the like.

Water has been proposed as the evaporative-cooling liquid for an $Li/SOCl_2$ battery that is being developed. The maximum operating temperature for this battery should be maintained below 100 to 110 °C. Water boils at 100 °C at atmospheric pressure and has a heat of vaporization of 2.3×10^6 J/kg. The battery has a total mass of 25 to 30 kg and contains nine cells, each of which produces an average of about 20 to 30 W of heat during a complete discharge lasting 5 h.

A first-order thermal analysis predicts that if the battery has an initial temperature of 50 °C, a total mass of 0.5 kg of water would suffice to limit the maximum temperature of the battery to 110 °C; 1.5 kg of water would suffice to limit the temperature to 100 °C. About 10 times these masses of a solid-to-liquid or solid-to-solid phase-change material would be required to achieve the same cooling effects.

In the spacecraft application for which this technique was originally conceived, the steam produced in cooling the battery would be directed via tubing to a small reservoir located near tanks containing liquid hydrogen and liquid oxygen. This very cold reservoir would condense the steam. This would prevent the steam from escaping and contaminating the spacecraft. In a terrestrial or other application in which contamination by steam is not an issue, the steam could be vented to the environment.

This work was done by Pradeep Bhandari and Robert N. Miyake of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 39 on the TSP Request Card.* *NPO-17805*

Dual-Diaphragm Tank With Leakage-Indicating Drain

Reliability would exceed that of a single-diaphragm tank.

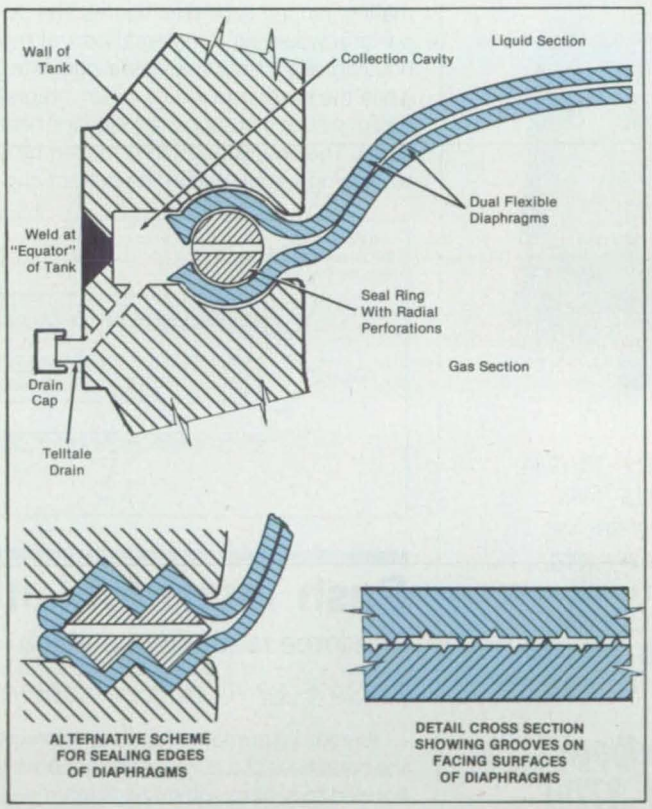
Lyndon B. Johnson Space Center, Houston, Texas

A proposed tank would include a dual diaphragm with a telltale drain to separate two fluids (e.g., a liquid and a pressurizing gas in a hydraulic power system). If a leak occurred in one diaphragm, the other diaphragm would still prevent the mixing of the two fluids; meanwhile, the leakage would accumulate in the drain and would alert an inspector to the need for repair.

The diaphragms would extend across the tank and would be sealed to the wall of the tank at its "equator" with conventional labyrinth compression seals. The edges would be separated by a perforated ring (see figure). The facing surfaces of the diaphragms would contain grooves that would generally lead radially outward from the axis of the tank. The groove patterns on the two diaphragms would be different so that the grooves would form fine channels between the faces. Any leaked fluid between the diaphragms would flow radially outward, pass through the perforations in the seal ring, enter a collection cavity, then flow out through the telltale drain. The inspector would remove the drain cap to check for accumulated fluid.

The two parts of the tank separated by the diaphragm would be equipped with fittings for filling and extracting fluid from the "poles." The shells would be welded together at the equator.

In a single-diaphragm tank, liquid tends to diffuse through the diaphragm into the gas section, where it displaces pressurization gas volume. Similarly, the gas tends to diffuse into the liquid section, where it dissolves in the liquid. The double diaphragm would provide a route for diffusants to escape so that each would not enter the opposite section. And, of course, it would provide redundant sealing in case of a puncture or tear, whereas a single diaphragm would allow immediate mixing. Moreover, the telltale drain would give instant evidence of leakage; time-consuming pressure-drop tests to verify the integrity of each diaphragm would be unnecessary.



Dual Diaphragms Would Flex as volumes of liquid and pressurizing gas change. Tiny channels between the diaphragms would carry away liquid and/or gas that leaks or diffuses through the diaphragms. Perforations in the sealing ring would carry the fluids to the collection cavity and the telltale drain.

In comparison with a dual-seal piston accumulator for separating liquid and gas, the dual diaphragm would last much longer. The piston seals ride on a dry cylinder wall as liquid volume changes and thus wear quickly and fail. The dual diaphragm would simply flex as volumes change. Furthermore, in many cases, the elastomeric materials that are most compatible with the fluids to be separated perform better as diaphragm materials than as sliding-seal materials.

Conceived for bladder tanks for use in zero gravity, the concept is adaptable to such commercial uses as hydraulic accumulators in industrial hydraulic systems, hydraulic systems in aircraft, and water pressure tanks.

This work was done by Wallace C. Tuthill, Jr., of **Johnson Space Center**. *No further documentation is available.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center [see page 16]. Refer to MSC-21703.

Heat-Transfer Coupling for Heat Pipes

The design of the coupler would avoid a difficult brazing operation.

NASA's Jet Propulsion Laboratory, Pasadena, California

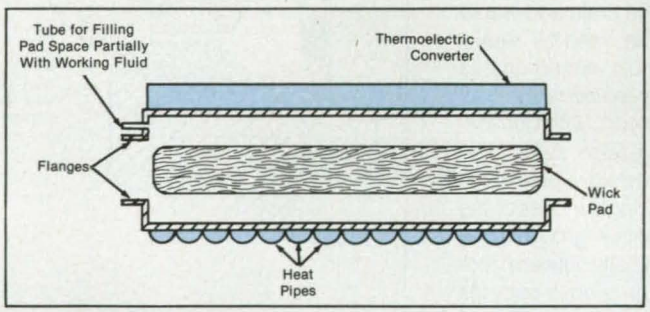
A proposed welded heat-transfer coupling would join a set of heat pipes to a thermoelectric converter. The design of the coupling would make it unnecessary to braze the heat pipes directly to the converter — a complicated, difficult operation that could damage the heat pipes and converter. Evacuating, filling, wetting-in, and testing would be required while the heat pipes are attached to the converter.

In the proposed coupling, the heat pipes could be prefilled. The heat of welding would be applied around the periphery of the coupling, far enough from the heat pipes so that it would not degrade the working fluid or create excessive vapor pressure in the pipes.

The coupling would include a pair of mating flanged cups (see figure). The upper cup would be an integral part of the housing of the thermoelectric converter, while the lower cup would be an integral part of a plate that supported the filled heat pipes. The coupling would be assembled by placing a wick pad in the bottom cup, placing the upper cup over the bottom cup, and welding the flanges together. The space inside the cups would later be filled with working fluid through a small tube, which would then be sealed.

The pad and working fluid would transfer heat efficiently between the thermoelectric converter and the heat pipes. The working fluid, wick pore size, and artery design could be chosen to suit the temperature and heat flux for the thermoelectric converter and the rate of failure of heat pipes. The pad and fluid would redistribute heat away from failed heat pipes and toward functioning heat pipes. This heat redistribution prevents the thermoelectric converters from becoming a resistive electrical load, which would occur if the converters were directly attached to a heat pipe that failed during operation.

This work was done by Bill J. Nesmith of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 7 on the TSP Request Card.*
NPO-17863



Halves of the Coupling would be welded together at flanges. The filled heat pipes would not be adversely affected by this operation. Working fluid moving through the wick pad would transfer heat from the thermoelectric converter to the heat pipes.

Push Tester for Laminated Films

The force required to crack a film is a measure of embrittlement.

NASA's Jet Propulsion Laboratory, Pasadena, California

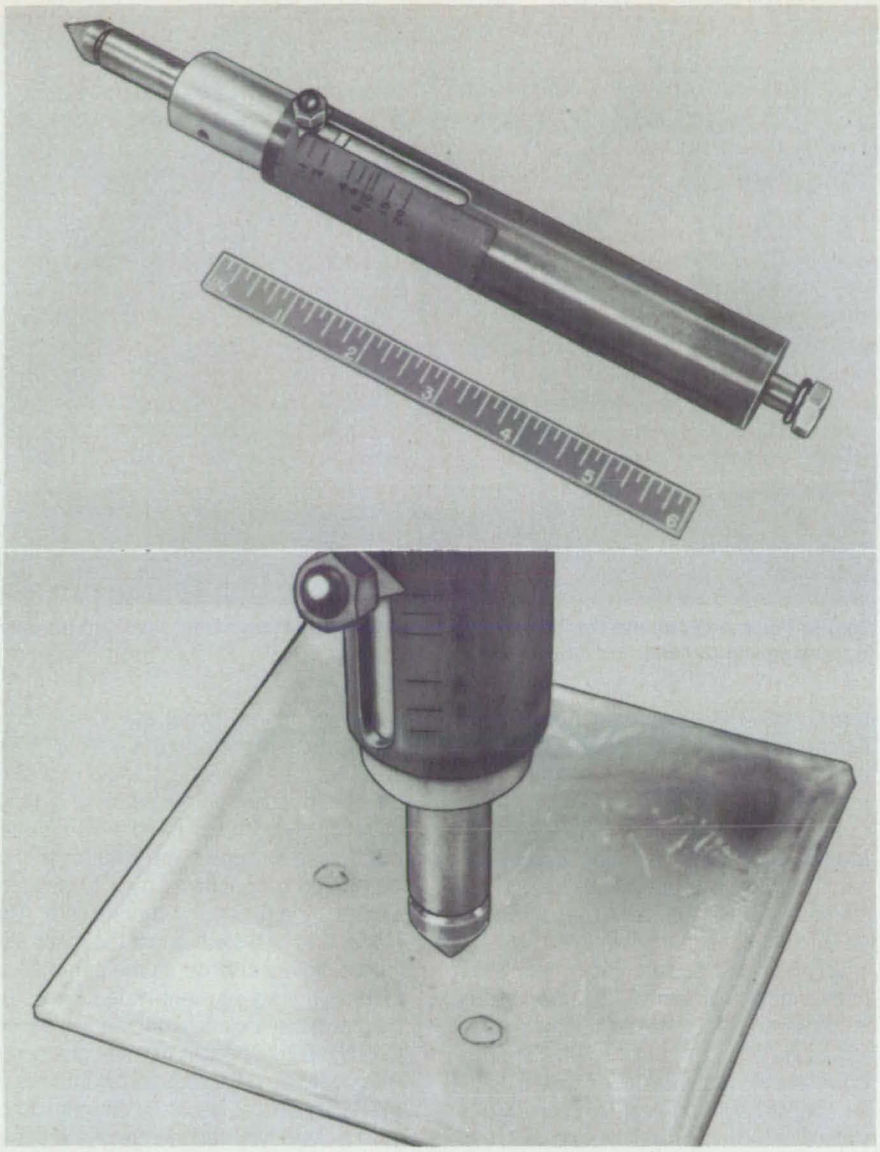
A small instrument is used to measure the brittleness of a polymer film adhesively bonded to a hard substrate. Such measurements are used, in turn, to measure the rates of embrittlement in environmental tests of candidate laminated-film covers for photovoltaic modules.

The instrument (see figure) is a microball push tester. It includes a spring-loaded, steel-ball tip, 0.0625 in. (1.58 mm) in diameter, that applies a known, adjustable force when the user presses it against the surface of a specimen. The user compares the depression left by the ball with that left in a specimen that has not been exposed to the aging environment. In an unexposed specimen, a depression is formed when the microball is pressed into it. In an exposed film that is becoming brittle, a smaller depression is formed, along with concentric cracks inside and around it. The greater the embrittlement, the lower the force required to cause cracking.

The microball tester has been used in tests of specimens exposed to accelerated aging under various combinations of temperature, humidity, and ultraviolet radiation. Specimens of the following types were evaluated:

- Transparent polyvinyl fluoride (PVF) film bonded to glass by use of ethylene vinyl acetate (EVA) as the adhesive;
- Transparent PVF bonded to amorphous silicon with EVA; and
- Transparent PVF bonded with EVA to a glass superstrate on a module of amorphous silicon.

In a photovoltaic module made with any



The **Penlike Instrument** has a microball tip. The small pointer in the slot on the side of the instrument is used to calibrate and indicate the spring force applied by the point. The microball dents only a small area of a specimen (bottom). For emphasis, depressions are marked here by surrounding circles.

of these combinations of materials, embrittlement of the film would eventually lead to cracking and result in deterioration of the module and exposure of the electrical circuit to the environment.

The microball tester is not limited to use on transparent films; it can be used on opaque laminated films on back panels of photovoltaic modules, for example.

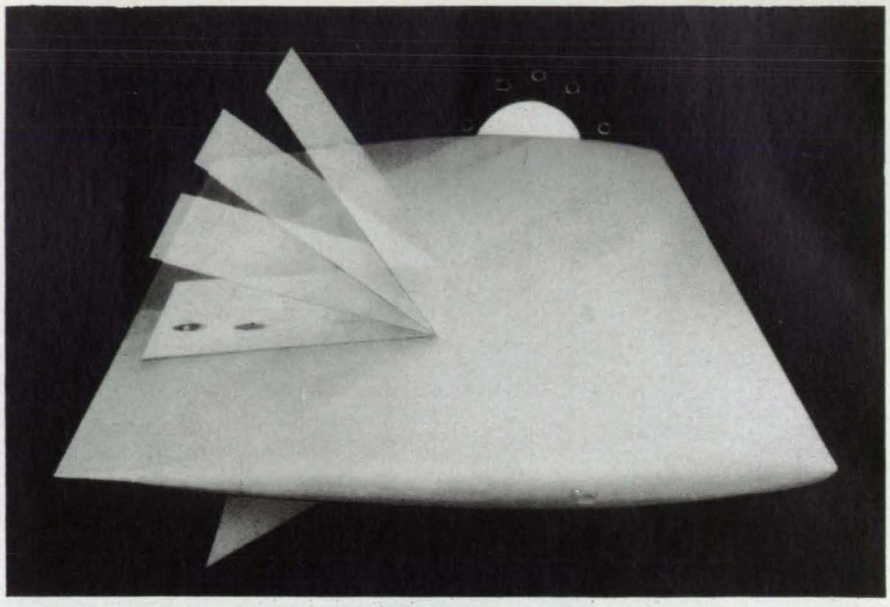
This work was done by Russell S. Sugimura of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 56 on the TSP Request Card.*
NPO-18063

Flutter Spoilers

Spoiling devices can be deployed rapidly to prevent damage to airfoil surfaces.

Langley Research Center, Hampton, Virginia

Flutter is an aeroelastic phenomenon in which a wing undergoes rapid bending and twisting oscillations under certain flight conditions. Flutter can lead to destruction of the wing. A number of methods used in flutter research and development tests minimize the risk of structural damage to test specimens. Although these methods may be effective in certain situations, no single method works effectively in all situations. The research engineer typically selects the method that best meets the



Spoiler Plates Rotate Into the Airstream, "spoiling" the aerodynamic flow and thereby increasing the dynamic pressure at which flutter occurs.

needs within the constraints of the particular test. The flutter spoiler represents an important addition to this repertoire of methods.

Flutter instability is produced by an unfavorable coupling of unsteady aerodynamic forces with structural inertia and stiffness forces. One way to suppress flutter is to increase the dynamic pressure at which the flutter occurs. The flutter spoiler does exactly this. When the flutter spoiler is deployed, the unsteady aerodynamic forces are changed and the flutter dynamic pressure is increased. Because the flutter spoiler could be deployed rapidly, the violent increase in vibration amplitude that usually occurs at flutter would be prevented from occurring.

A flutter spoiler consists of one or more platelike structures hinged along its leading edge to the surface of a wing or other lifting surface so that the spoiler can be rotated outward into the airstream. An example is shown in the photograph. Typically, flutter spoilers would be located on both the upper and lower airfoil surfaces, but could be used on either. When not in use, the flutter spoilers would fold against or into the wing surface so that the aerodynamic contour of the wing would remain unchanged.

When the flutter condition is reached, the flutter spoiler would be rapidly deployed, rotating about its upstream end so that it would "spoil" the aerodynamic flow on the surface of the wing. It could be deployed by hydraulic, electrical, mechanical, pneumatic, or a combination of means. It could be under the remote control of a test engineer or under automatic control coupled to a sensing device that would measure vibratory response and actuate the flutter spoiler when a preset level of vibration occurrs.

A wind-tunnel-model study was conducted to demonstrate the effects of the size and the deployment angle of a simple flutter spoiler on the flutter of a wing. A relatively simple, paddle-type flutter model was equipped with a flutter spoiler that could be deployed over a range of angles by adjusting a mechanism. The model was ballasted so that the mass and inertia did not change as the parameters of the flutter spoiler were varied. Thus, the natural frequencies remained the same. Consequently, changes in flutter characteristics between different configurations of the flutter spoiler could be directly attributed to aerodynamic effects of the flutter spoiler.

Experimental results were obtained at mach 0.80 for (1) variations in the angle of deployment of the flutter spoiler, the area of which was constant at 0.047 that of the wing, and for (2) variations in the size of the flutter spoiler for a given angle of deployment. Results show that the flutter dynamic pressure is increased by increasing either the angle of deployment or the size. The results further show that the size has a stronger effect on flutter than does the angle of deployment over the range of parameters investigated.

The use of the flutter spoiler would be particularly attractive for wind-tunnel flutter-model tests, in which models are tested at conditions very close to, or in many instances at, the flutter boundary because it is necessary to define accurately the flow conditions at which flutter occurs. The use of the flutter spoiler would prevent damage to these flutter models, which are often very expensive.

This work was done by Robert V. Doggett, Jr., of **Langley Research Center**. *For further information, Circle 70 on the TSP Request Card.* *LAR-14117*

Improved Force-and-Torque Sensor Assembly

Forces and torques are measured by different strain gauges at different positions.

NASA's Jet Propulsion Laboratory, Pasadena, California

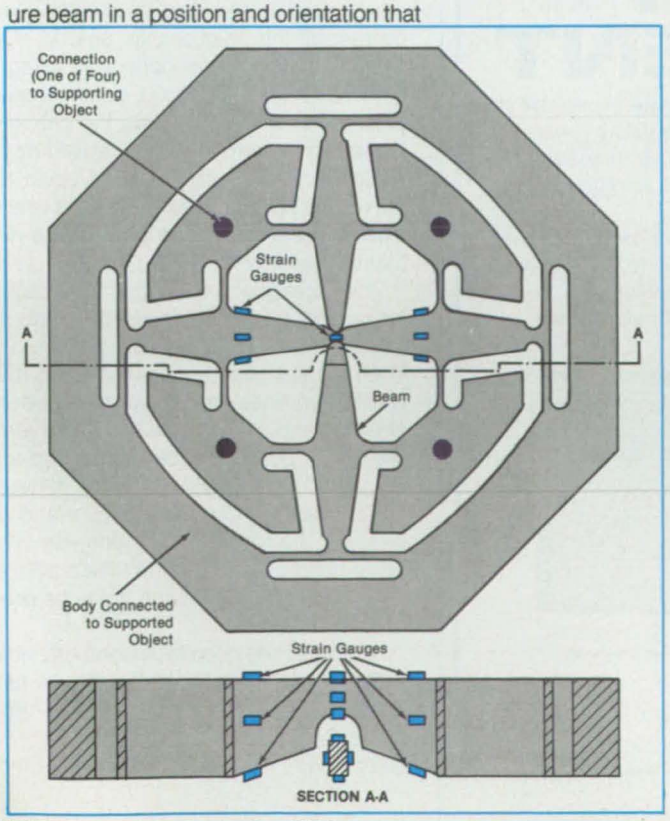
An improved sensor assembly measures the forces and torques of interaction between a supporting and a supported object. For example, the assembly could be placed at the wrist of a robot to measure the operating loads between the arm and hand. Like many prior force-and-torque sensor assemblies, this one includes strain gauges mounted on flexure beams in positions and orientations that make them sensitive to strains proportional to the forces and torques to be measured. The immediate predecessor of the improved sensor assembly was similar in that it had a four-flexure beam configuration, but it was relatively insensitive to axial forces, and it was necessary to extract axial-force data from the outputs of the same strain gauges that also measured the torques.

The improved assembly (see figure) is sensitive to all three components of force and all three components of torque. In this sensor assembly, the strain gauges that measure the forces are separate from the ones that measure the torques. The force-measuring gauges are positioned and oriented to be insensitive to torques, while the torque-measuring strain gauges are mounted to be insensitive to forces.

Each strain gauge is mounted on a flexure beam in a position and orientation that makes it sensitive to a component of longitudinal strain indicative of bending of the beam about one of its axes. In this configuration, pure torque loads do not cause bending of the crossed flexure beams at the axis of symmetry. However, force loads along or perpendicular to the axis of symmetry do cause these beams to bend at the axis of symmetry. Consequently, the strain gauges near the axis of symmetry are not sensitive to torques but are sensitive to forces.

Torque loads do cause the beams to bend at the points near the thin webs that join them to the connection to the supporting object. Consequently, the strain gauges at these points measure torque loads. Force loads also cause some bending at these points, but the strain gauges here are less sensitive to force loads than are the strain gauges at the axis of symmetry. In any event, these gauges can be connected in a bridge circuit, or their outputs can be processed in such a way as to cancel the force readings.

This work was done by Robert M. Bamford of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 46 on the TSP Request Card.*
NPO-17370



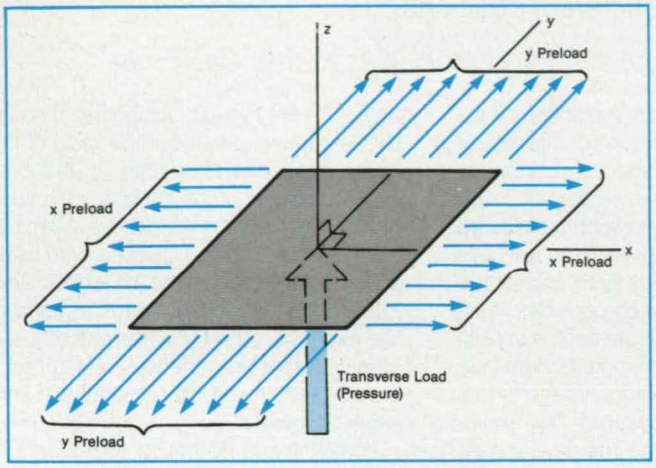
The **Improved Force-and-Torque-Sensor Assembly** measures all three components of force and all three components of torque. The force measurements are uncoupled from the torque measurements. The price for the improved measurement capability is complexity and flexibility that could be excessive in some applications.

Deflection and Stress in Preloaded Square Membrane

The effect of tension applied uniformly along edges is added to the analysis.

Goddard Space Flight Center, Greenbelt, Maryland

A theoretical analysis has yielded equations for the transverse deflection of, and the stresses in, a square membrane subject to both a uniform transverse load (e.g., the difference between the pressures in two fluids separated by the membrane) and tension preloads applied uniformly along the edges (see figure). Previous theoretical analyses by Foppl and Timoshenko included the assumption of zero edge preload, and Foppl's analysis included a calculation of the maximum deflection for the special case of a Poisson's ratio of ¼. The new analysis and equations are valid for any Poisson's ratio.



Uniform Stretching Preloads are applied to the edges of a transversely loaded square membrane, possibly to reduce the transverse deflection. Previous analyses addressed the effects of the transverse load but did not consider preloads.

The analysis is performed in a simple *x, y, z* coordinate system, with origin at the center of the square defined by the edges of the membrane: *x* and *y* each parallel to one of the two perpendicular pairs of edges, and *z* perpendicular to *x* and *y*. Like the previous analyses, this one follows an energy/virtual-displacement approach. In this approach, the basic equation is one that expresses the strain energy in the membrane as a double integral, over the *x* and *y* coordinates of the square, of a function of the longitudinal strains, the shear strain, the thickness of the membrane, and the Young's modulus and Poissons's ratio of the membrane material.

Following standard practice, it is assumed that the edges of the membrane are held rigidly and that the *x, y,* and *z* components of the displacement caused by the transverse load can be represented by simple trigonometric expressions that reduce to zero displacement at the edges. The *x* and *y* (stretching) components of the displacements caused by the preloads are added (the *x* preload can differ from the *y* preload) to obtain the total displacements.

The first and second derivatives of the expressions for the total displacements are used to derive expressions for the strains in the strain-energy integral. Then, using the principal of virtual displacement, an equation for the relationship between the in-plane (*x* and *y*) and the transverse (*z*) displacements is found by setting the derivative of the strain-energy integral with respect to the amplitude of the transverse-load component of the in-plane displacements equal to zero. Next, an equation that expresses the relationship among the maximum transverse deflection at the center, the transverse load, and the edge preloads is found by setting the change in the strain-energy integral caused by a virtual transverse displacement equal to the work done by the transverse load when it deforms the membrane by the same virtual displacement.

The expressions derived in the foregoing procedure are inserted in the previous equations for the displacements and strains. Then the stresses are expressed via the well-known linear relationships between stresses and strains. The maximum tensile stress occurs at the edges, and an equation for this stress has been derived for the special case of equal *x* and *y* preload. The results of this analysis can be compared to the results of the previous analyses by simply setting the edge preloads to zero.

This work was done by Alfonso Hermida of **Goddard Space Flight Center**. *For further information, Circle 47 on the TSP Request Card.*
GSC-13367

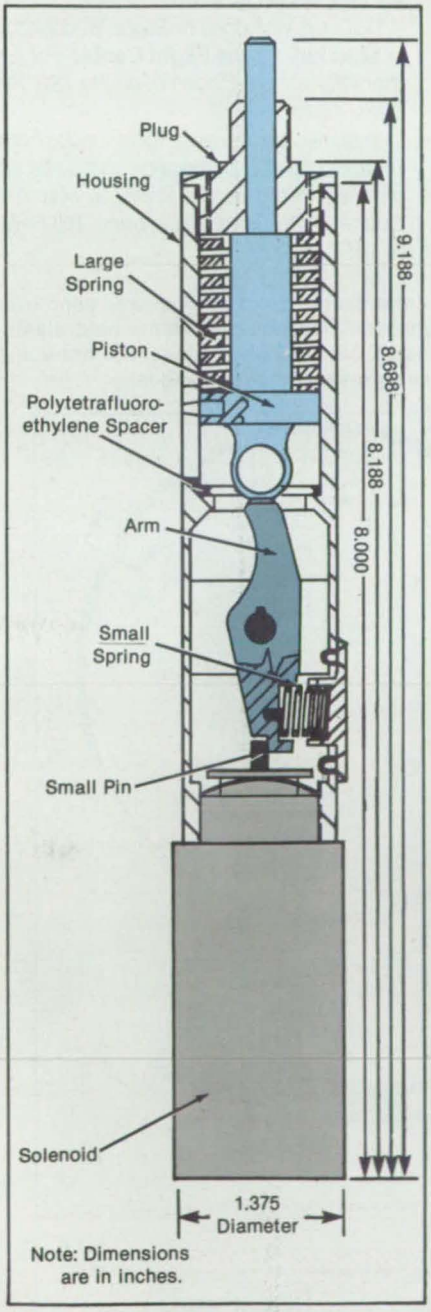
Reusable Mechanical Pin Puller

The puller can be used in the testing of systems that normally use expensive pyrotechnic pullers.

Goddard Space Flight Center, Greenbelt, Maryland

A reusable, mechanical pin puller (see figure) was designed to save money and increase safety as a substitute for costly and potentially dangerous pyrotechnic pin pullers used in the development and testing of deployment mechanisms. In the development of the Cosmic Background Explorer Spacecraft, launched in 1989, mechanical pin pullers were designed to use in place of the 28 pyrotechnic pin pullers, each costing $500 to $1,000, in three deployable systems: a solar array, a thermal shield, and an antenna. Versions of the mechanical pin puller could be used in other mechanisms that would normally be activated by pyrotechnic pin pullers.

Designed to exert a pull of 250 lb (1,100 N), the pin puller includes a cylindrical housing that contains a piston, a large spring, and a trigger mechanism. The trigger mechanism includes an arm that keeps the piston loaded against the compressed large spring until the time of activation. A small spring keeps the arm loaded against a small pin protruding from a solenoid until the time of activation. Upon retraction of the small pin by the solenoid at the time of activation, the small spring turns the arm away from the piston, and the large spring drives the piston downward through a distance of about 0.5 in. (12.7 mm) onto a polytetrafluoroethylene spacer.



The **Reusable Mechanical Pin Puller** is a relatively simple spring-loaded trigger mechanism.

To prepare the pin puller for reuse, one disassembles the top portion of the mechanism, replaces the spacer, reassembles the top portion, and reloads the piston against the large spring while cocking the arm against the small spring. The large spring can be changed to change the pull.

This work was done by Son Ngo and Rodger Farley of **Goddard Space Flight Center** *and Ed Devine of Swales Associates. No further documentation is available. GSC-13355*

Long-Lived, Replaceable Low-Pressure Seals

Simple units operate by metal-spring and elastomeric compression.

Marshall Space Flight Center, Alabama

A type of gasket suitable for use on hatches and windows combines the advantages of low leakage, long life, and easy replacement. A typical gasket of this type consists of a metal spring plate with an elastomeric jacket (see figure). The K-shaped cantilever springs on the plate hold the jacket against the structure to be sealed. The light spring force on the jacket ensures a tight, low-leakage seal, even in vacuum and extreme cold. The flanges to be sealed to each other by the gasket can thus be made smaller and lighter than if a metal-to-metal contact were used. The elastomer is subject to only moderate compression force and therefore lasts longer than a purely elastomeric gasket does because it does not acquire as much of a compression set.

The gasket is used between two flat flanges to be sealed to each other; e.g., one on a window or hatch and the other on the supporting structure. Fasteners on the window flange retain the gasket, maintaining a light load on it and thus securing the elastomer jacket when the two flanges are separated. When the flanges are brought together, the spring arms begin to deflect and carry load. This continues until the gasket plate contacts both flanges, at which point the seal is fully compressed. Any further load that tends to push the flanges together is taken up by the gasket plate. The seal is a double one; a barrier to flow is maintained at both flanges.

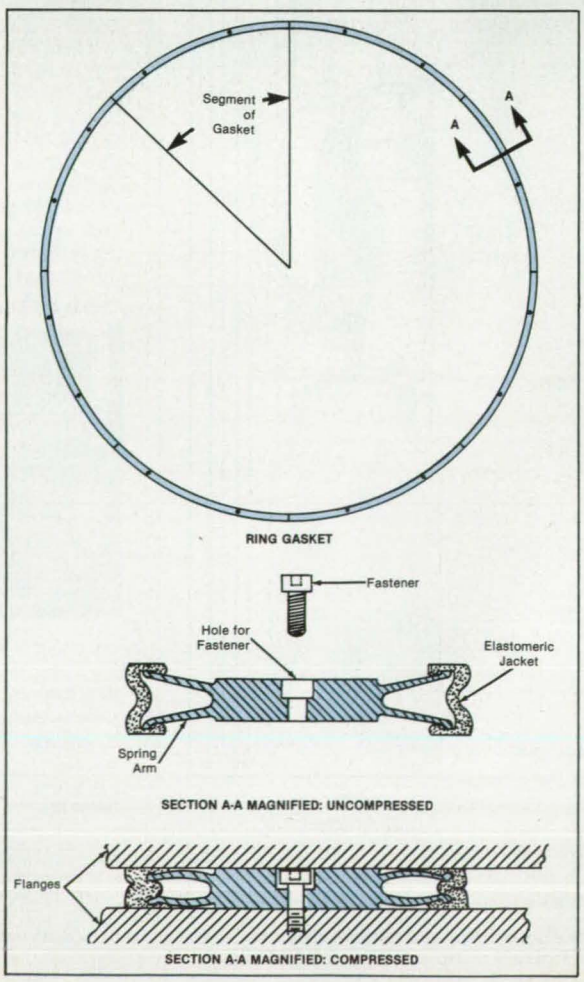
The elastomer jacket supports itself when it is compressed. It thus provides some degree of seal even if one of the spring arms fails.

When a jacket eventually deteriorates and must be replaced, the sealed flanges are separated and the fasteners are loosened. This makes it easy to slip the jacket off the spring arms. The flanges can be cleaned easily; it is not necessary to pry an O-ring out of a dovetail groove. A new jacket is slipped on the arms, the fasteners are retightened, and the flanges are rejoined. Replacement jackets can be folded and stored in a small space.

This work was done by Bruce Weddendorf of **Marshall Space Flight Center**. *For further information, Circle 10 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 16].Refer to MFS-28521.

The Ring-Shaped Gasket has a rectangular cross section from which paired cantilever spring arms extend in a K-shape. In the unassembled state, the arms hold elastomeric jackets lightly but securely. When assembled between flanges, the arms and jackets become compressed and form an airtight seal on both flanges.



Machinery

Hardware, Techniques, and Processes

Books and Reports

Anthropomorphic Robot Hand and Teaching Glove

Motions of the operator's fingers control motions of the corresponding robot fingers.

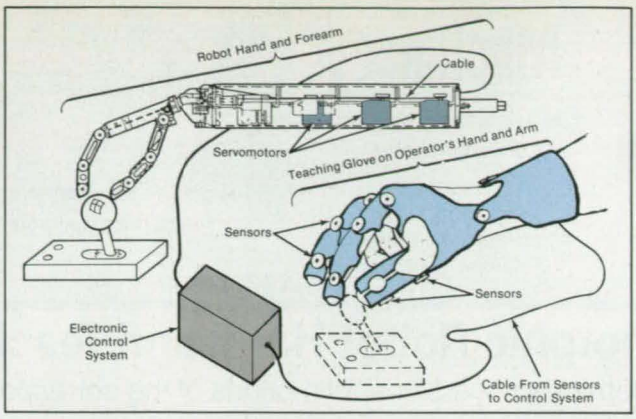
Goddard Space Flight Center, Greenbelt, Maryland

A robotic forearm-and-hand assembly manipulates objects by performing wrist and hand motions with nearly human grasping ability and dexterity. The robot imitates the hand motions of a human operator who controls the robot in real time by programming via an exoskeletal "teaching glove" (see figure). Telemanipulator systems based on this robotic-hand concept could be useful where humanlike dexterity is required. Underwater, high-radiation, vacuum, hot, cold, toxic, or otherwise inhospitable environments are potential application sites. The system is particularly suited to assisting astronauts on a space station in safely executing unexpected tasks requiring greater dexterity than the standard gripper has.

The robot hand is anthropomorphic and, more importantly, anatomically correct in size and configuration. Finger and thumb digits are sized and proportioned like those of an average human hand. A bracket emulating the palm precisely positions the digits with respect to each other.

Just as the motions about the various joints of a human hand are actuated by muscles in the forearm pulling on tendons, the motions about the joints of the robot hand are caused by servomotors in the robot forearm pulling on cables made from Technora, a fiber similar to Kevlar. Each motor actuates the motion about one of the joints in response to a processed control signal or to a real-time sensed position of the corresponding joint of the operator's hand.

The design was based on human anthropometry studies, which suggest that skeletal characteristics of the human hand vary only slightly from person to person, differences being primarily in size (scale). The importance of human "anatomical consistency" for the field of robotics is twofold; namely, as a method of control and gripper dexterity. By building an anatomically correct mechanical model of the human hand, robot control then evolves from primitive teach pendant to utilization of teach glove. Placed over the operator's own hand, object manipulation now be-



The **Anthropomorphic Robot Hand and Teaching Glove** are parts of a telemanipulator system that can handle objects with a dexterity approaching that of the human operator.

comes a function of operator intuition, with skills and talents inherently provided to accomplish the task.

This work was done by Charles D. Engler, Jr., of **Goddard Space Flight Center**. *For further information, Circle 155 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Goddard Space Flight Center [see page 16]. Refer to GSC-13244

Unbalanced Rotating Masses for Scanning

Scans can be performed with less power and at less cost.

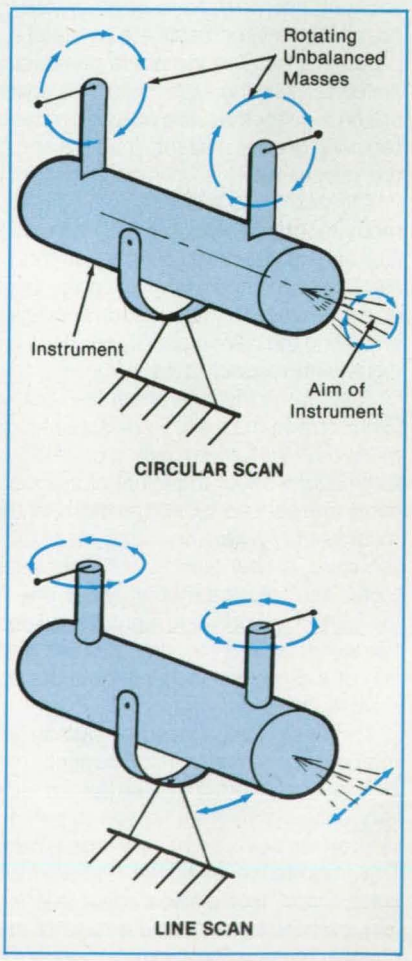
Marshall Space Flight Center, Alabama

Unbalanced rotating masses could be low-cost, low-power, lightweight means of generating scanning torques for scientific instruments. They could impart a variety of scanning patterns — continuous circular, back-and-forth linear, and, with the aid of an indexing mechanism, raster. A system of unbalanced rotating masses has been proposed for scanning gimbaled sensors that will observe the Sun from a balloon-borne gondola. Two unbalanced masses would move the sensor aim in a circular pattern around the center of the Sun (see figure).

A rotating-unbalanced-mass device would consist of a mass on a lever arm rotating at a constant angular velocity. The centrifugal force of the rotating mass would create a torque about the center of gravity of the gimbaled platform. The torque would move the platform and sensors in the requisite scanning pattern. A torque motor, a device tachometer, a resolver or encoder, and feedback control electronics would be used to make the device rotate at constant angular velocity.

In a system like that of the balloon-borne experiment, the motions of the two unbalanced masses would have to be synchronized electronically so that their rotations would produce the required effect.

Compared with older scanning systems, rotating-unbalanced-mass systems offer important advantages. In the balloon experiment, for example, reaction wheels



Rotating Unbalanced Masses would produce linear or circular scans. The scanning rate would be determined by the sizes of the moment arms and the rotational velocities.

would consume much more power — 174 W versus 21 W for the unbalanced masses. Reaction wheels would also be more expensive. Thrustors are more expensive and rely on limited supplies of propellant. Torque motors used to rotate entire platforms (instead of only the unbalanced masses) generate reaction torques in the supporting structure, which can disturb the experiment.

Reaction wheels, thrustors, torque motors, or control-moment gyros would still be needed to center scans or for indexing them in rasters. However, the torques needed for these purposes would be low, and the units would be small.

This work was done by Michael E. Polites of **Marshall Space Flight Center**. *For further information, Circle 94 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 16]. Refer to MFS-28425.

Self-Motion Manifolds of Redundant Manipulators

A new perspective on redundancy can yield alternative control strategies.

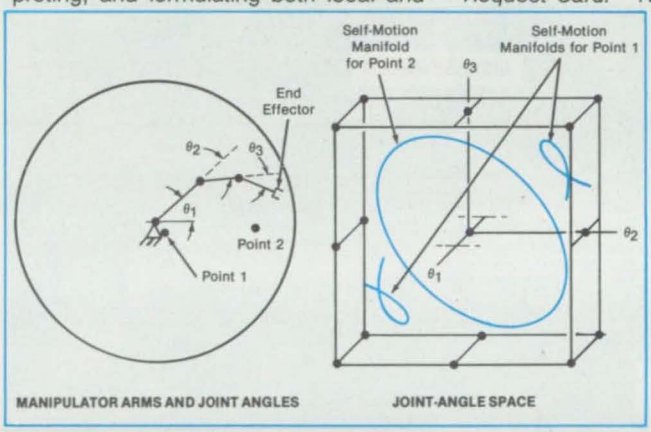
NASA's Jet Propulsion Laboratory, Pasadena, California

Self-motion manifolds are introduced in a new approach to the characterization of self-motions of a robotic manipulator that has redundant degrees of freedom. Self-motions, which are made possible by the redundancy, are those motions of the robot joints that leave the position of the end effector unchanged. In much of the previous research on redundant manipulators, the approach has been to resolve the redundancy by optimizing the redundant motions of the joints with respect to additional criterion functions while commanding the end effector to follow the desired trajectory.

The previous approach has involved the use of a pseudoinverse of the Jacobian matrix (which consists of derivatives of the coordinates of the end effector with respect to the coordinates of the joints) in optimizing locally — that is, within a small range of redundant motions. In the alternative approach, the kinematics of the robot are reformulated via a manifold mapping that stresses global, rather than local, kinematic analysis. Within this theoretical framework, the infinite number of redundant solutions of the inverse kinematic problem (the problem of finding the trajectories of the joints as functions of the desired trajectory of the end effector) are naturally interpreted as a set of self-motion manifolds (see figure) rather than in terms of the Jacobian null space.

This approach is useful in the study of redundant manipulator kinematics. In addition, the problem of the resolution of redundancy can be posed equivalently in this approach as the problem of the control of self-motions, and the self-motion manifolds are useful in investigating, interpreting, and formulating both local and global techniques for the resolution of redundancy. Redundancy can be resolved by direct control of a set of self-motion parameters, by direct control of a related set of kinematic functions defined by the user and the use of these functions to construct an augmented Jacobian, or by optimization with an objective function.

This work was done by Joel W. Burdick and Homayoun Seraji of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 136 on the TSP Request Card. NPO-17965*



The **Self-Motion Manifold** of a three-arm planar robotic manipulator with the end effector located at point 2 is a closed curve in the three dimensional space of the joint angles. For point 1, there are two manifolds — both spiral lines.

Books and Reports

These reports, studies, handbooks are available from NASA as Technical Support Packages (TSP's) when a Request Card number is cited; otherwise they are available from the National Technical Information Service.

Variable-Speed Instrumented Centrifuges

Image and data recording and controlled temperature and gravity would be provided for 12 experiments.

A report describes a conceptual pair of centrifuges, the speed of which could be varied to produce a range of artificial gravities in a zero-gravity environment. The microprocessor-controlled centrifuges would include video cameras to record stop-motion images of experiments.

The centrifuge speed would be variable from 0.66 to 75.6 r/min, creating accelerations ranging from 0.0001 to 1.3 times the gravitational acceleration at the surface of the Earth. Potential applications of the machine include studies of the effect of gravity on the growth and on the production of hormones in corn seedlings, experiments with magnetic flotation to separate cells, and electrophoresis to separate large fragments of deoxyribonucleic acid.

Each centrifuge would be independently controlled and would accommodate six experiments. Sliprings would provide power and signal lines for the experiment containers. The microprocessor would control the speed, temperature, displays, and the recording of images and data. It would consist of a central processor on a mother board, a variety of circuit boards custom-designed for the experiments, and a digitizer to transfer video data to disks.

The video cameras would include charge-coupled devices that can store images in their memories in less than one-sixtieth of a second. One camera would be provided for each centrifuge. Infrared light would be flashed on an experiment container, and the camera would record the image. The image of a rapidly moving object would not be blurred but merely elongated in the direction of motion. This distortion could be removed, if necessary, by subsequent data processing.

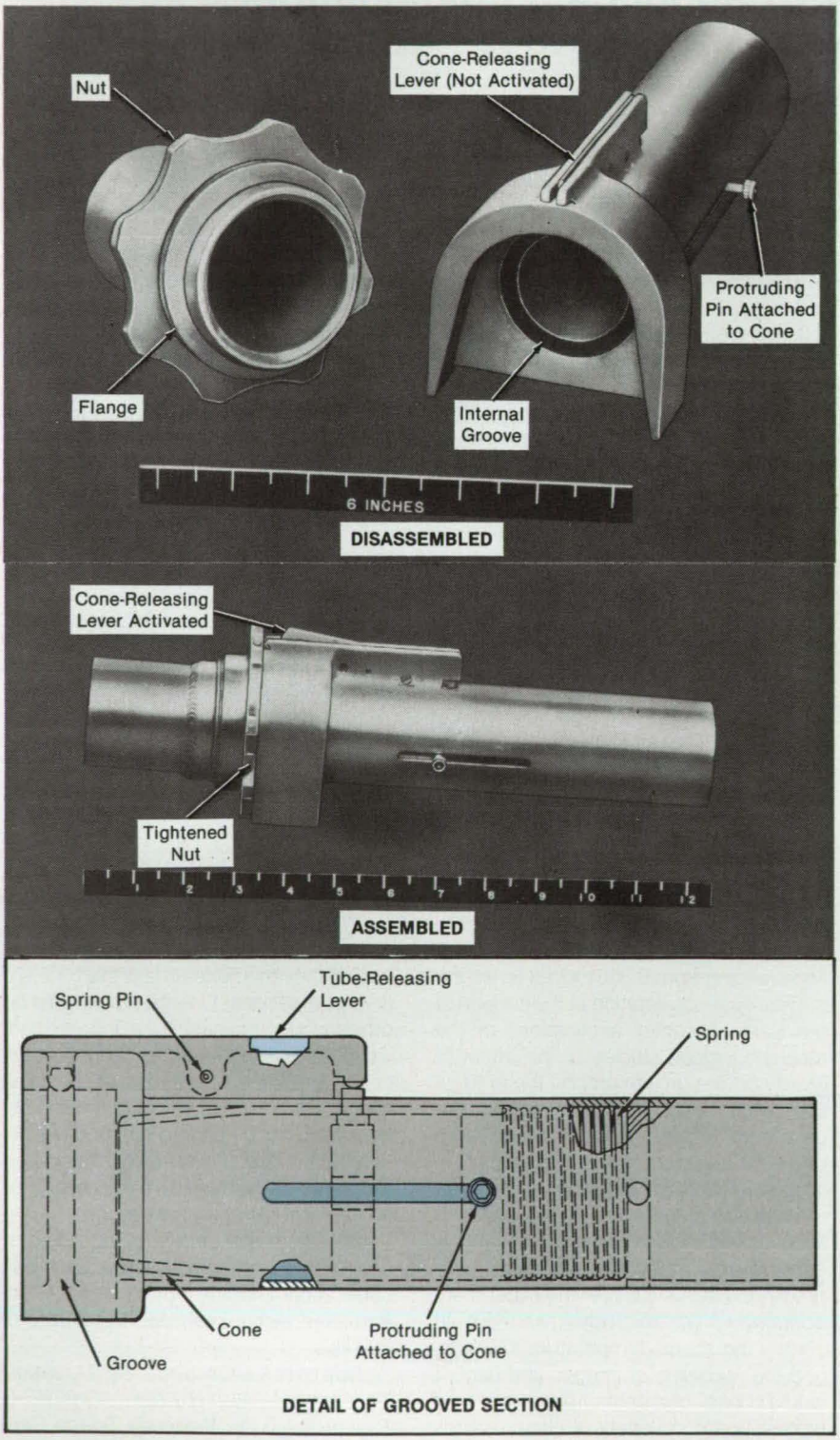
Video and other data would be stored on two 3.5-in. (8.9-cm) floppy disks. Each disk could accommodate more than 3.2 Mb of formatted digital information at a rate of 500 kb/s.

This work was done by David K. Chapman and Allan H. Brown of MICRO-G Research Inc. for **Kennedy Space Center**. *To obtain a copy of the report, "Variable Speed Mid-Deck Centrifuge," Circle 42 on the TSP Request Card. KSC-11383*

Fabrication Technology

Hardware, Techniques, and Processes

Quick-Connect/Disconnect Joint for Truss Structures



Halves of the Connector are shown before (top) and after (middle) assembly. The drawing of the grooved half (bottom) shows the spring-loaded cone in its unreleased position. When the flanged half is inserted in the groove, it moves the lever of the trigger mechanism upward. The cone then shoots into the grooved half.

A simple connector could be used for temporary structures and pipes.

Lyndon B. Johnson Space Center, Houston, Texas

A truss connector joins and aligns structural members. The connector can be attached without tools in less than 2 seconds and can be taken apart just as quickly and easily. Developed for assembling structures in outer space, the connector may also be useful for temporary terrestrial structures like scaffolds and portable bleachers. With modifications, it could be used to join sections of pipelines carrying liquids or gases.

The connector consists of two sections, one flanged and the other with a mating internal groove (see figure). As the flanged half is inserted in the grooved half, the two sections bring themselves into axial alignment. Simultaneously, the flange activates a trigger mechanism that releases a spring-loaded cone that is concentric with the grooved section. The cone slides from the grooved section into the flanged section, locking the halves together. A large nut on the flanged half is tightened by hand against the grooved half to secure the connection.

A pin is mounted on the cone and extends out from a slot on the grooved section. It thus shows the position of the tube; the pin is at far end of the slot (away from the joint) before the flange is inserted, and it is at the near end after the flange has released the cone.

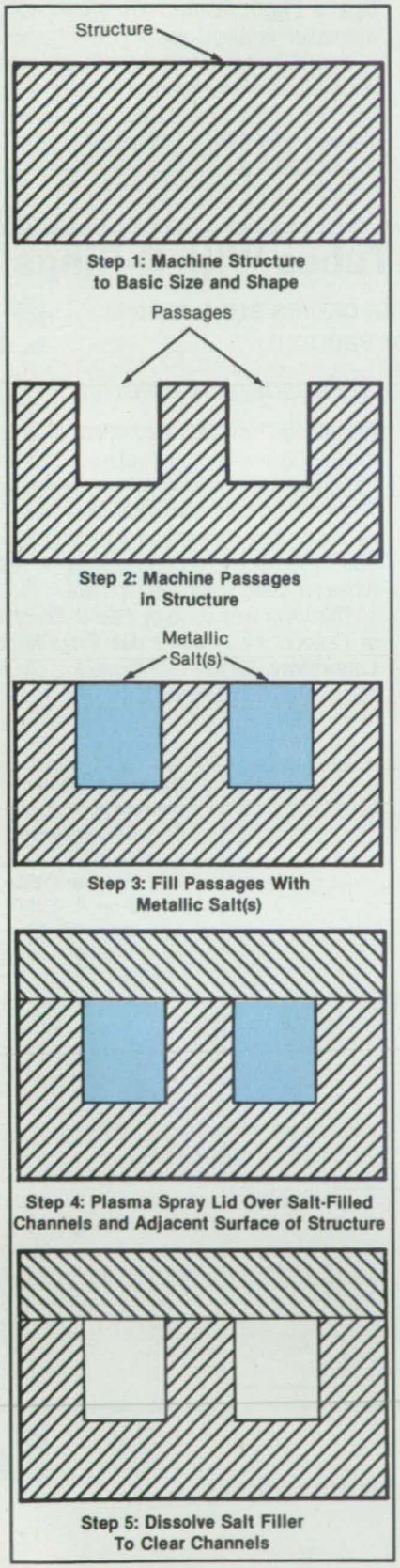
The pin can also be used to open the connector. The operator returns the pin to its original position, thereby reloading the cone against its spring, and loosens the nut. The sections can then be pulled apart.

This work was done by Benny B. Sprague of **Johnson Space Center**. *For further information, Circle 164 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center [see page 16]. Refer to MSC-21539.

Salt Filler for Making Covered Channels

Metal salts offer ease of application, resistance to high-temperature processing, and ease of removal.



Machined Channels Are Filled With Salt, which serves as a substrate for a plasma-sprayed metal lid. The salt is then rinsed away from under the lid to clear the passages.

Marshall Space Flight Center, Alabama

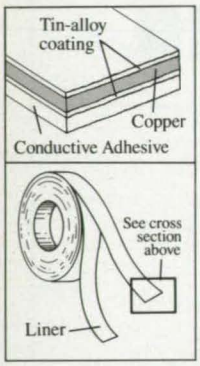
In a simple fabrication technique, metal salts are used to create such subsurface channels as those for coolant in a metallic heat exchanger. Metal salts are readily available, are easy to apply, and can be removed easily and quickly. Previous filler materials have included waxes, which are easily removable by melting at low temperatures but, therefore, may not withstand high temperatures used in fabrication; and aluminum, which can withstand higher temperatures but has to be removed by dissolving it in acid.

Open channels are first machined in the metal heat exchanger or other structure (see figure). The metal salt or mixture of salts, which may be crystalline, powdered, or granular, is mixed with a small amount

3M Reveals New Long Term EMI/RFI Shielding Tape

Tin-alloy coating on both sides of copper foil offers superior solderability, environmental stability.

AUSTIN, Tex. – This new UL Recognized Scotch™ Foil Shielding Tape 1183 employs a tin-alloy coating on smooth copper foil to produce a durable and effective electromagnetic shield.



The tin-alloy coating is on both sides of the copper for thorough protection.

The tape is a tin-alloy coated version of the widely used 3M 1181 Tape and provides shielding when wrapped around flat and round cable, and cable connectors.

The unique electrically-conductive adhesive enables 1183 tape to make electrical connections across seams and between mating sections, of electronic enclosures ranging from small equipment housings to large shielded rooms. The tape can also shield the energy radiating from seams between the sectors of dish antennas.

The special tin-alloy coating on both sides of the foil provides two significant benefits.

1. Thorough environmental stability and corrosion resistance.
2. Exceptional solderability for applications such as sealing the seams when the tape is used as a shield around cable connectors.

3M 1183 Tape also serves as a corrosion resistant contact surface for conductive gasketing, beryllium copper "spring fingers" or other resilient conducting media used around doors and openings of electronic cabinetry.

For more information about all 3M Foil Tapes, contact a 3M Electrical Specialties Division representative or authorized distributor or call 1-800-233-3636.

3M Electrical Specialties Division
PO Box 2963
Austin, TX 78769-2963

3M

of water or other solvent, and the resulting paste is placed in the open channels. The structure is heated in an oven to dry the paste.

A layer of metal is deposited on the structure by vacuum plasma spraying, sealing the channels. The metal salt or salt mixture has a melting temperature higher than those of waxes and aluminum and, therefore, can withstand the high temperature of plasma spraying. After plasma spraying, the salt filler is dissolved quickly and easily and flushed away with water or other appropriate solvent, leaving behind the covered channels.

This work was done by Timothy N. McKechnie and Richard R. Holmes of Rockwell International Corp. for **Marshall Space Flight Center**. *No further documentation is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 16]. Refer to MFS-29729.

Sealing Out-of-Round Tubes With O-Rings

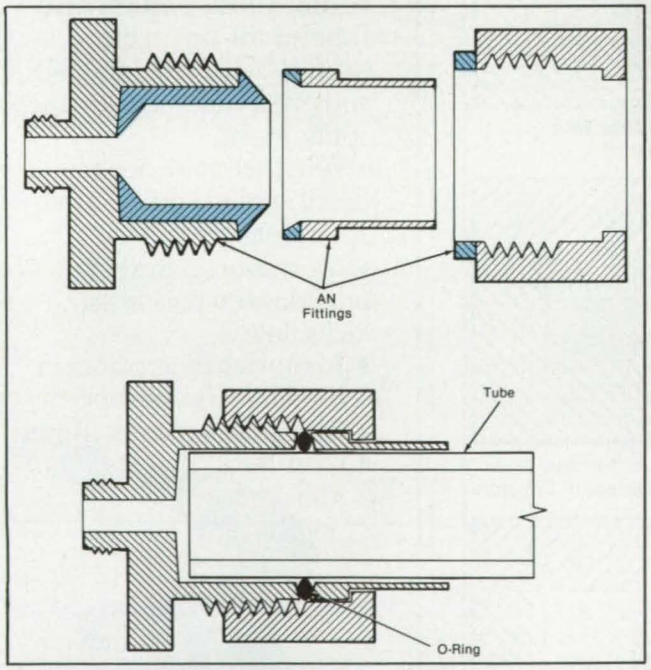
Shells of connectors for electrical cables are adapted to seal tubes against pressure or vacuum.

NASA's Jet Propulsion Laboratory, Pasadena, California

Glass or ceramic tubes that are out-of-round can be sealed effectively by ordinary O-rings in caps of modified hydraulic fittings. In a typical connection, the O-ring is squeezed between two surfaces that have inward-opening slants of 5° or 10° (see figure). The slanted surfaces force the ring inward, compressing it around the tube. The connector metal fitting, tightened by hand around an O-ring, can seal the O-ring against a tube as much as 1/16 in. (1.6 mm) out of round.

Standard aluminum or stainless-steel AN fittings can be readily adapted by machining small amounts of material from the ends of the mating parts (see figure). The modified connectors can seal glass or ceramic tubes against gas or vacuum leakage in furnaces, vacuum systems, and tubes for glassblowing equipment.

This work was done by Paul J. Shlichta of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 156 on the TSP Request Card.*
NPO-17791



Parts of AN Connectors (top) are machined to remove material shown in color. The parts are then mated so that they squeeze an O-ring inward against a tube (bottom).

Staking Pliers

Pliers with a simple modification deform threads quickly, easily, and inexpensively.

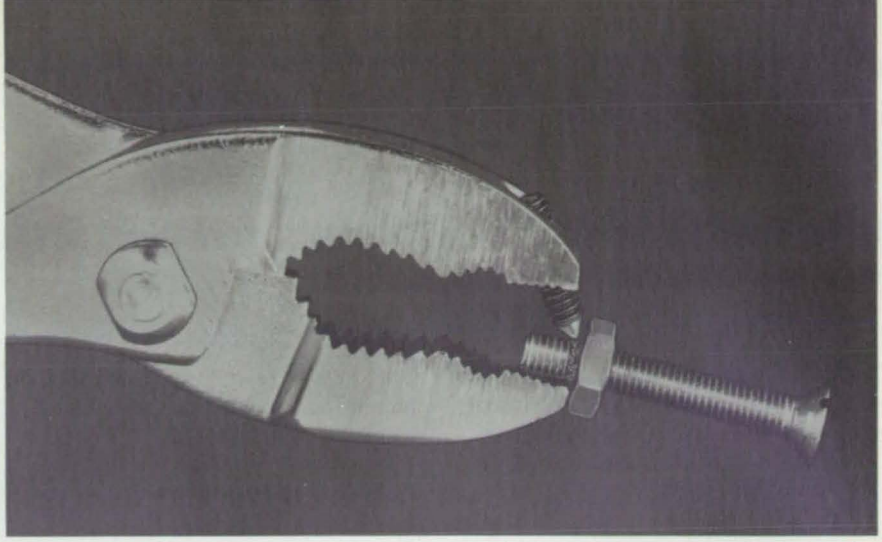
Lyndon B. Johnson Space Center, Houston, Texas

A modified pair of ordinary pliers deforms the thread on a bolt after a nut has been screwed on it. The deformed threads prevent a loosened nut from backing off under vibrations or impact. The staking pliers are used in place of the center

punch and hammer formerly used to stake (deform) the thread. In comparison with the center punch and hammer, the pliers are easier and faster to use and less likely to damage parts.

The modification consists of (1) drilling and tapping a hole in one of the jaws and inserting a hardened setscrew with a sharply ground point in the hole and (2) putting a notch in the tip of the opposing jaw (see figure). When the jaws are clamped on a bolt, the point of the setscrew is driven into the thread, reshaping it so that the inside thread of a nut can no longer slide on it. The notch in the jaw opposite the setscrew centers and holds the bolt while the point presses into it.

This work was done by Elwood S. Falls of **Johnson Space Center**. *For further information, Circle 14 on the TSP Request Card.* *MSC-21725*



Ordinary Pliers are modified by the addition of a hard-pointed setscrew in one jaw and a groove in the opposite jaw. When the jaws are squeezed together on a bolt, the point deforms the thread.

Pressure Roller for Tape-Lift Tests

A simple, easy-to-use tool provides more nearly uniform pressure.

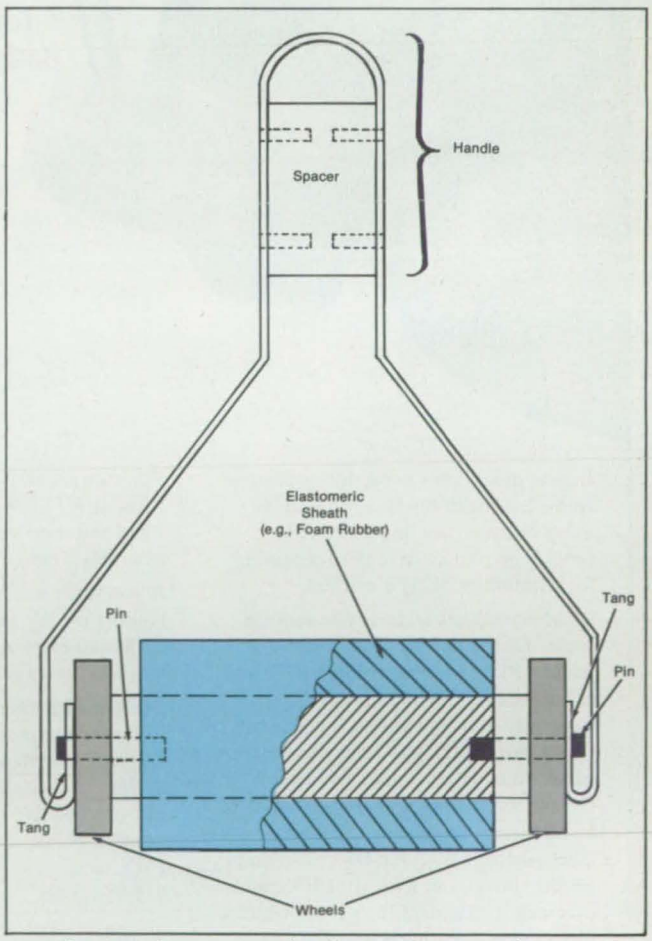
Goddard Space Flight Center, Greenbelt, Maryland

A rolling device applies a nearly constant, uniform pressure to a surface. The device is intended for use in taking tape-lift samples of particulate contamination on the surface.

Heretofore, the usual method of taking such a sample has been to lay the sticky side of an adhesive tape on the contaminated surface, smooth it with the fingers, then remove the tape, and examine it under a microscope to determine the number and size of contaminant particles. With this method, however, it is practically impossible to ensure that a constant pressure is applied evenly over the tape when it is smoothed. Therefore, particles may cling more in certain areas and less in others, and the accuracy of the measurement becomes questionable.

The rolling device is used in place of the fingers to ensure that nearly the same pressure is applied over the entire area of the tape. The pressure applied is also independent of the user. The device includes a sheath of foam rubber or other suitable elastomeric material on a cylinder that has wheels at its ends. The cylinder is mounted to rotate on a handle (see figure). The diameter of the wheels is greater than that of the cylinder but less than that of the sheath. The user grasps the handle of the device and pushes it against the surface, compressing the sheath until the wheels make contact with the surface. The user thus compresses the foam a fixed amount, and consequently the foam applies a nearly constant pressure to the surface. The foam also conforms to slight irregularities of the surface.

Keeping the wheels in contact, the user rolls the sheath across the tape to apply the pressure for the collection of particles. The inspection for contamination is thus done under consistent, repeatable conditions.



This **Simple Tool** exerts a nearly constant pressure via compression of the sheath by a fixed amount. Pins hold the wheels on the cylinder and the cylinder on the tangs of the handle. The cylinder and handle can be made of metal or plastic. The sheath can be press-fit or glued to the cylinder. The end pins can be attached to the cylinder by adhesive or screw threads.

The pressure can be changed in either of two ways:

- Changing the diameter of the wheels. A smaller diameter increases the pressure, while a larger diameter decreases it (eventually reaching zero when the diameter of the wheel matches that of the sheath).
- Changing the thickness or the material of the sheath. For example, a stiffer foam rubber applies greater pressure for a

given distance of compression.

This work was done by Eve Abrams **Goddard Space Flight Center**. *For further information, Circle 20 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Goddard Space Flight Center [see page 16]. Refer to GSC-13230.

Initiating Growth of Crystals Away From Container Walls

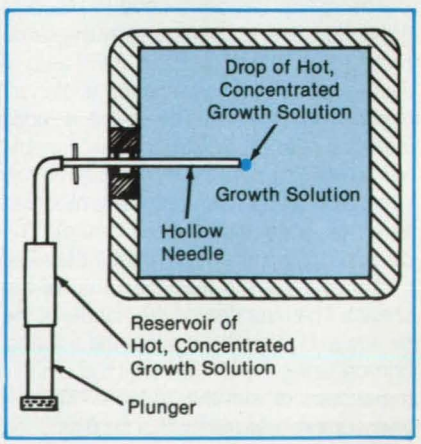
Nucleation would be controlled to obtain better crystals.

Marshall Space Flight Center, Alabama

In a technique proposed specifically for growing large protein crystals in microgravity (where there is no thermal convection), a small region of high supersaturation would be created by injection of hot concentrated solution or by use of a cold probe. The crystals would nucleate preferably in this small region. It is also at least conceivable that this technique could be applied on Earth to crystallizations in melts and solutions that are sufficiently viscous to suppress convection to the extent necessary to prevent cooling-induced nucleation in undesired sites.

Heretofore, nucleation in microgravity has typically been induced by cooling the walls of a growth chamber to cool a saturated or nearly saturated solution in the chamber. Because the solution near the walls becomes supersaturated first as the cooling diffuses inward through the solution, many crystals form first on the walls, which undesirably modify the growth of these crystals. Furthermore, the sizes of resulting crystals are undesirably limited because the solution is rapidly depleted of solute.

In the first version of the proposed technique (see figure), a plunger controlled by a micrometer would force a drop of hot, highly concentrated solution from a reservoir into a body of less-concentrated (but nevertheless at least slightly supersaturated) growth solution. Provided that there was negligible convection and the thermal diffusivity was greater than the mass diffusivity, the injected drop would cool and become highly supersaturated before its concentration could be reduced by diffusion of mass into the surrounding less-concentrated growth solution. Nucleation would then occur for a short time. After nucleation, diffusion of mass would cause the region of high supersaturation to dissipate. The degree of saturation surrounding the nuclei of the crystals would then return to the ambient value, preventing further nucleation. Diffusion-controlled growth of the few crystals nucleated in this region



Nucleation of Crystals would be induced in the growth solution by injection of a drop of hot, highly concentrated solution to form a small, highly supersaturated region away from the walls.

would then proceed without interference from surfaces.

In the second version of the proposed technique, a rod with cold tip would be inserted into the supersaturated growth solution. Nucleation would occur in the small region of cooled solution near the tip, and the growth of the resulting crystal(s) would deplete the solute from the region of the solution adjacent to the growing faces; this region would remain stable in the absence of convection. Provided that thermal diffusion in the solution is faster than is mass diffusion (as is usually the case), the solution adjacent to the depleted region would cool and become highly supersaturated before mass diffusion depleted this part of the solution also. Nucleation would then occur in this region, the effect being similar to that of the hot-fluid-injection technique.

This work was done by Roger L. Kroes, Donald A. Reiss, and Sandor L. Lehoczky of **Marshall Space Flight Center**. *For further information, Circle 16 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 16]. Refer to MFS-28473.

Gradient Tempering of Bearing Races

Fracture toughness is increased, and stress-corrosion cracking reduced.

Marshall Space Flight Center, Alabama

A gradient-tempering process could increase the fracture toughness and the resistance to stress-corrosion cracking of ball-bearing races that are made of hard, strong steels and that are subject to high installation stresses and operation in corrosive media. This process could also be used in other applications in which local toughening of high-strength/low-toughness

Figure 1. **Heat Applied Radially to the Bore** of a bearing race causes gradient tempering, which increases its resistance to stress-corrosion cracking.

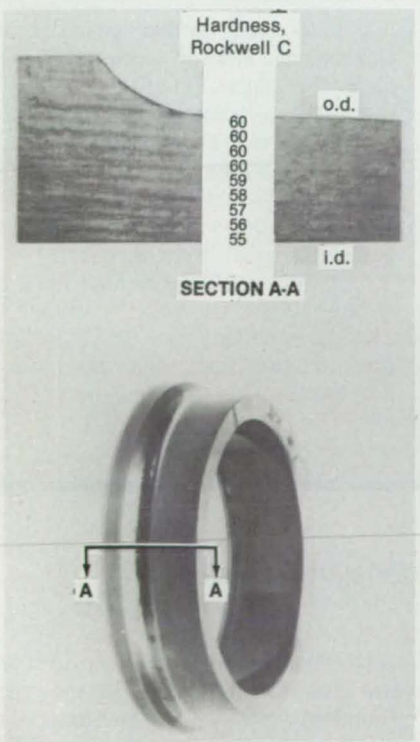


Figure 2. The **Gradient Tempering** of the bearing race is projected to yield this hardness gradient.

materials is required. This toughening reduces the strength of the toughened regions, but provided that it is properly localized, it should not significantly degrade the load-carrying capacities of the treated parts.

The gradient-tempering process was conceived for use on the races of bearings in a turbopump in the Space Shuttle main engine. Heretofore these races have been processed in a manner that has remained basically unchanged for many years. They have been machined, austenitized, tempered, and low-temperature-soaked, then subjected to a final tempering operation. These typical thermal treatments impart uniform hardnesses through the thicknesses of the races. Unfortunately, the typical uniform hardness of 60 Rockwell C entails susceptibility to failure in two modes: stress-corrosion cracking and the growth of precritical cracks and other defects.

The most effective way to protect a bearing race or other part against failures in these modes is to increase its fracture toughness and decrease its strength in such critical regions as sharp corner radii and the inner surfaces of holes. This is accomplished by the gradient-tempering operation (see Figure 1), in which a highly localized intense flux of heat is used to bring about localized tempering without affecting the surrounding bulk of the material and without causing such damage as melting or the growth of grains in the tempered section. The flux of heat is directional and can be provided, for example, by a laser, or by an electromagnetic-induction device. Figure 2 shows the projected hardness gradient of the race of Figure 1 after tempering by this process.

This work was done by Richardson A. Parr of **Marshall Space Flight Center**. *For further information, Circle 115 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 16]. Refer to MFS-28496.

Ultrasonic Device Would Open Pipe Bombs

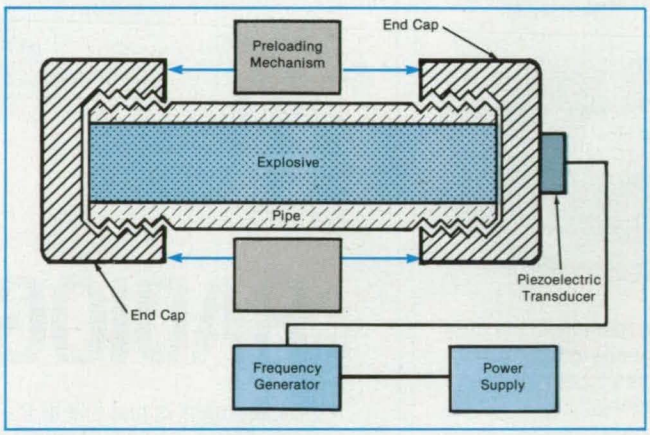
A conceptual device would safely remove end caps.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed piezoelectric vibrator would assist in disabling homemade pipe bombs with little or no risk of explosion. Clamped to the ends of the bomb, the device would send high-frequency, low-amplitude sound waves into a threaded cap (see figure). The waves would generate fatigue cracks at the roots of the pipe thread. The cracks would grow and sever the threaded end from the pipe body. The caps could then be safely removed.

Almost all pipe bombs include steel pipe and end caps purchased at hardware stores. In a typical bomb, an explosive or conflagrating material is placed in the pipe, the caps are screwed on, and a detonation fuze is inserted through a hole in one of the caps. Bomb-disposal technicians disarm the bomb by removing the fuzed cap. Currently, they do this by obliquely directing a water jet or a slug of dental amalgam and steel shot at a point on the edge of the fuzed cap. This shears the pipe at the thread. However, it produces a sudden, large deformation at the point of impact that can easily transmit a stress pulse that detonates the bomb material.

The piezoelectric transducer in the proposed disabling device would vibrate at an ultrasonic frequency that would resonate only the steel shell, not the material inside. The approximate frequency would be calculated from the dimensions and geometry of the standard piping parts used in the bomb. This calculation is expected to be within 5 percent of the proper value. The device would scan frequencies within this range and sense the resonance; it would then hold this resonant frequency until the pipe breaks. The best position for the transducer would also be determined from the geometry of the piping.



A **Piezoelectric Ultrasonic Transducer**, energized by a frequency generator and a power supply, would vibrate the shell of a pipe bomb while hardly disturbing the explosive inner material. Frequency-control circuitry would sense resonance in the shell and hold the generator at that frequency to induce fatigue cracking in the threads of the end caps.

Before energizing the transducer, the bomb technician would attach a preloading mechanism to apply an outward force on the caps. The force would eject the fuzed cap from the explosive material at the moment of fracture.

In addition to its use in disarming bombs, ultrasonically induced fatigue may have other applications. In manufacturing, it might replace some machining and cutting operations. In the repair of equipment, it could cleanly and quickly disassemble corroded parts. In the demolition of buildings it might be used to dismember steel framework safely and controllably.

This work was done by Michael S. El-Raheb, Marc A. Adams, and James G. Zwissler of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 107 on the TSP Request Card. NPO-17951*

Composite-Material Airflow Vane

A lightweight replacement for a balsa-wood part produces more-consistent results.

Langley Research Center, Hampton, Virginia

"Alpha/beta" lightweight instrumentation vanes made of a composite of phenolic, epoxy, and fiberglass are stronger and more accurate than are conventional vanes made partly of balsa wood. The vanes are used for measuring the direction of airflow over aircraft surfaces during flight testing. The older, balsa-wood vanes were difficult to fabricate, broke easily, and changed in weight and shape as temperature and humidity varied, yielding unreliable data.

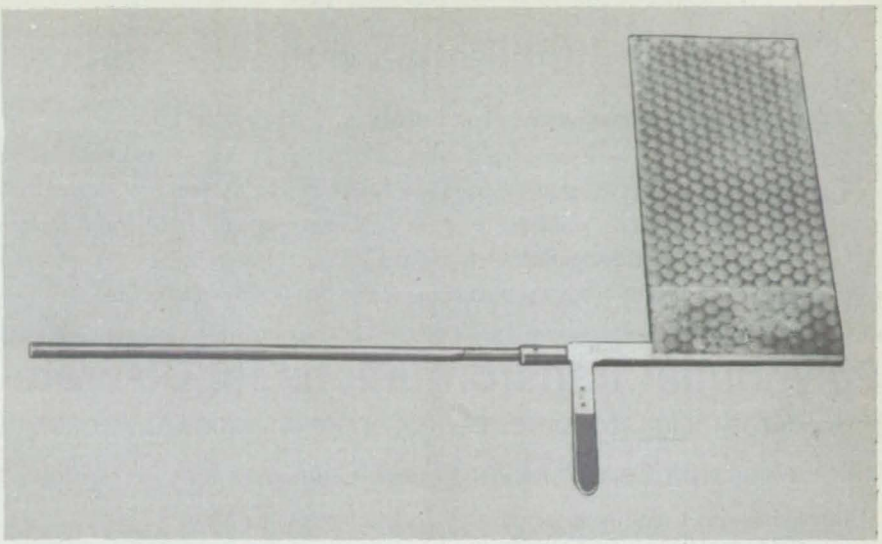
A vane of the new type consists of a sandwich of phenolic honeycomb between fiberglass skins. Each skin is molded from two layers of 0.0015-in. (0.038-mm)-thick fiberglass cloth with the weave oriented at 45° to the longitudinal axis of the vane. The honeycomb structure, which is 1/8 in. (3.2 mm) thick and has cells spaced 3/16 in. (4.8 mm) center to center, is bonded to the

skins with epoxy adhesive.

Fabrication begins by placing the dry fiberglass cloth layers into the prepared mold cavity and carefully wetting the glass with epoxy resin. A silicone rubber plunger is used to apply pressure until the resin has cured. The honeycomb is then bonded to the skin surface with epoxy resin and allowed to cure. The next step is to remove the workpiece and bond it to the remaining cured skin with epoxy resin in a similar manner. A steel stem is bonded to the vane with epoxy adhesive. Finally, an over-wrap of 0.0015-in (0.038-mm) fiberglass cloth is applied around the stem and vane with epoxy resin (see figure).

The fabrication time for the new vanes is far less than for the old ones, because it is no longer necessary to select balsa wood manually to ensure the quality of the material. Moreover, many vanes can now be made at once in a gang mold.

The all-synthetic-material vanes absorb little or no moisture and thus provide more repeatable measurements. Because they weigh about the same as balsa vanes do, no instrumentation changes are needed. If a vane should break away from its stem, it is not likely to damage an aircraft engine if ingested; it will more likely crumble into low-density particles that pass through without causing harm.



This **Airflow Vane on a Stem** has a phenolic honeycomb core sandwiched between fiberglass/epoxy skins. Its dimensions are 4.750 × 2.375 in. (120.6 × 60.3 mm).

This work was done by Thomas L. Vranas of **Langley Research Center**. *No further documentation is available.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center [see page 16]. Refer to LAR-14192.

Microwave Levitation of Small Objects

Feedback control and an atmosphere would not be needed.

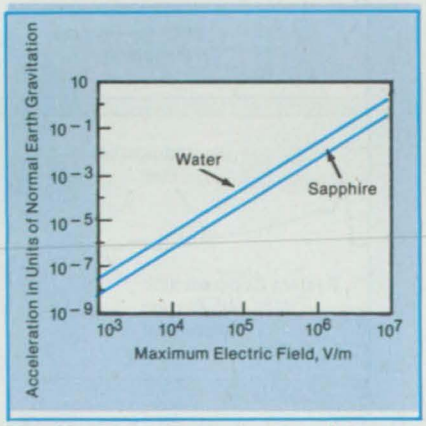
NASA's Jet Propulsion Laboratory, Pasadena, California

Microwave radiation in resonant cavities would be used to levitate small objects, according to a proposal. This technique was conceived for use in experiments on the processing of materials in the low gravitation of outer space, but it could also be used in normal Earth gravitation, albeit under some limitations.

In principle, almost any electrically polarizable material could be levitated by microwaves. Unlike in magnetic or electrostatic levitation, no feedback control system would be required to keep the levitated object at a position of stable equilibrium. Unlike in acoustic levitation, it would not be necessary to maintain an atmosphere of a particular gas at a particular temperature and pressure in the levitation chamber; indeed, under many conditions it could be preferable or even essential to maintain a vacuum in the chamber.

The principle of microwave levitation is reminiscent of that of acoustic levitation in that the time-averaged square of the magnitude of the electric field plays a role analogous to that of the time-averaged square of the acoustic pressure. A small object that has an electric permittivity greater than that of the atmosphere (this is always true if the atmosphere is a vacuum) experiences a net time-averaged dielectrophoretic force in the direction of increasing magnitude of electric field; more specifically, the time-averaged force is proportional to the gradient of the time-averaged square of the electric field.

Exploiting this principle, the dimensions of the levitation chamber, the frequency of the microwave signal, and the method of coupling the signal into the cavity would be chosen to excite a resonant electromagnetic mode or modes in which there would be at least one position, away from the walls, from which the magnitude of the electric field would decrease in all directions. Such a position can be found by analysis of the electromagnetic modes of the chamber. A particle that was initially placed at this position and that started to drift away would be driven back to the position by the restoring gradient force. Thus, no feedback control would be necessary to maintain stable equilibrium.



The **Maximum Restoring Accelerations** of levitated 1-mm spheres of water and sapphire were calculated as functions of the maximum microwave electric field in a 10-cm cubic cavity.

The problem has been analyzed theoretically for a cubic cavity 10 cm on each side, with a levitated drop of water or particle of sapphire 1 mm in diameter. The figure shows the calculated maximum restoring acceleration as a function of the maximum electric field in the chamber. With superconducting chamber walls, one can achieve electric fields of about 10^7 V/m, for which the restoring acceleration is of the order of normal Earth gravitation. Thus, it should be possible to test the technique on Earth.

In practice, the usable electric field will probably be limited by dielectric breakdown of the gas (if any) in the cavity and/or by microwave heating of the levitated object. Other considerations in the design of experiments include the choice of shapes and modes of the chamber to obtain steeper field gradients, the use of a frequency at which heating would be minimized, the use of superconducting chamber walls to obtain higher fields and/or decrease the required power, and forces on levitated objects of finite size and complicated shape.

This work was done by John L. Watkins and Henry W. Jackson of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 35 on the TSP Request Card.* *NPO-18006*

Mathematics and Information Sciences

Polynomial Transformations for Discrete-Time Linear Systems

Procedures for least-squares best-fit approximations have been developed.

Ames Research Center, Moffett Field, California

Transformations based on polynomial matrices of finite degree have been developed for use in computing functions for the compensation, inversion, and approximation of discrete-time, multivariable, linear systems. These transformations are applicable to cascade-compensation problems in the design of control systems. In such a problem, one system is cascaded with another represented by a polynomial transfer matrix to obtain a third system that behaves as desired. Mathematically, this amounts to finding the polynomial transfer-function matrix ("transfer matrix" for short), which, when convolved with the transfer matrix of the system, yields the desired transfer matrix, exactly or approximately.

The transformation method is derived from the z-transform transfer-function form of the matrices. The first step is to prescribe a measure of the difference between the convolution and the desired transfer function (the "approximation error"). This measure is called the "L_2 norm," and the equation that describes it is manipulated into a form in which the least-squares approximation can be applied to obtain a global optimum (a minimum of the approximation error) with respect to the coefficients of the polynomial transfer matrix. The result of this manipulation is a linear matrix equation called the "normal equation," which is similar to the equation of the same name that arises in the filtering problem.

The coefficients of the normal equation and the minimum approximation error are expressed in closed, explicit forms that can be shown to be the weighting patterns of various linear systems. These systems can, in turn, be used in the recursive solution of the normal equation to obtain the coefficients of the desired polynomial transfer matrix.

For example, suppose that the problem is to compensate a single-input/single-output system that has the transfer function

$$\Omega(z) = \frac{(z+0.2)(z-0.5\ \pm 0.2j\,)(z+0.02\ \pm 0.1j\,)}{(z-0.2)(z+0.1)(z+0.6\ \pm 0.3j\,)(z-0.1\ \pm 0.3j)}$$

by a polynomial compensator $\phi(z)$ so as to approximate a system that has the desired transfer function.

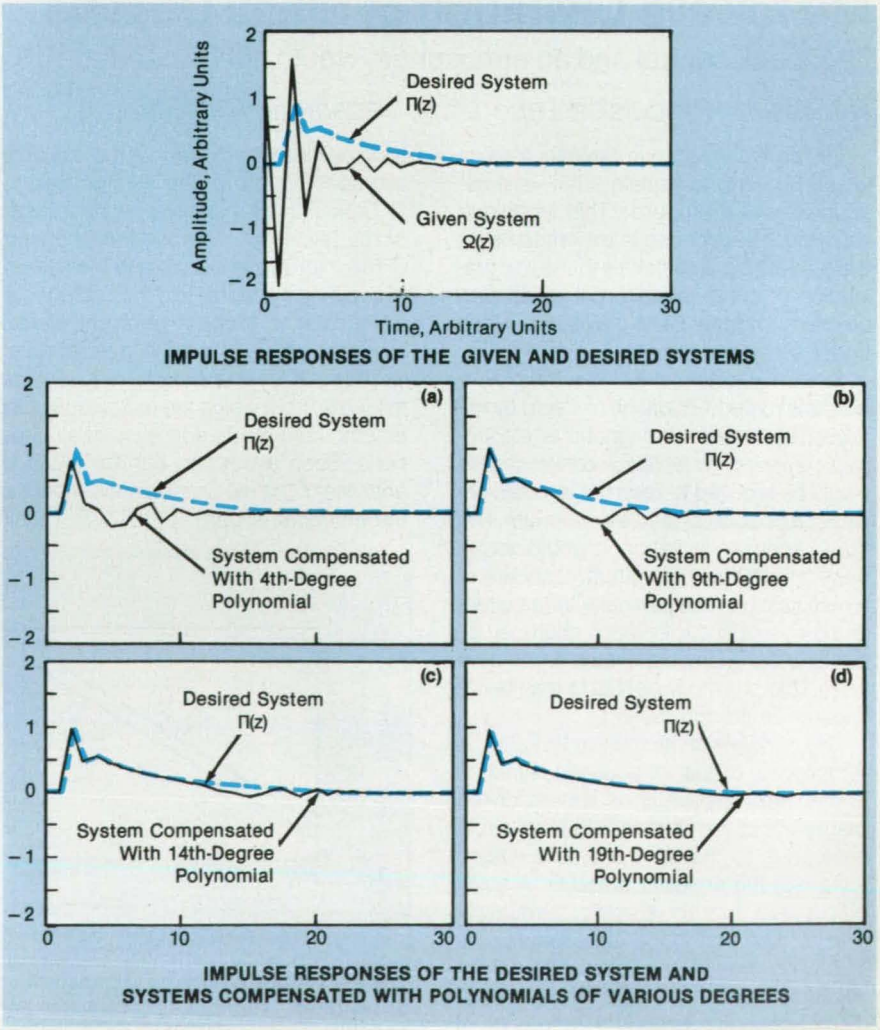
$$\Pi(z) = \frac{1}{(z+0.3521)(z-0.8521)}$$

The figure illustrates the impulse responses of the given system $\Omega(z)$, the compensated system $\Omega(z)\phi(z)$, and the desired system $\Pi(z)$; as it clearly shows, the response approaches the desired response as the degree of the polynomial increases.

This work was done by Yoram Baram of **Ames Research Center**. *Further information may be found in NASA TM-100027 [N88-12344], "Polynomial Compensation, Inversion, and Approximation of Discrete-Time Linear Systems."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.

ARC-12204



The **Impulse Response** of the given system is altered with polynomial compensators to make it behave like a desired system to various degrees of approximation.

Parallel-Processing Algorithms for Dynamics of Manipulators

Inertia matrix is computed more efficiently.

NASA's Jet Propulsion Laboratory,

Pasadena, California

A class of parallel and parallel/pipeline algorithms is presented for more efficient computation of the manipulator inertia matrix. Efficient computation of the inertia matrix is essential for implementing the advanced dynamic control schemes as well as the dynamic simulation of the manipulator motion. At the present, however, the fastest serial algorithms for computing the inertia matrix are far from adequate for efficient real-time dynamic control and simulation. Hence, the exploitation of parallelism in the computation of the inertia matrix is the key factor in achieving the required efficiency.

The parallel algorithms are derived based on a new algorithm for computing the inertia matrix, the Composite Rigid-Body Spatial Inertia algorithm, which, compared to the previous algorithms, incorporates less data dependency in the computation and hence provides a greater efficiency for parallelization. Two parallel algorithms are developed that achieve the time lower bound of $O(\log_2 n)+O(1)$ in the computation with $O(n^2)$ processors. These algorithms are designated as the First Parallel Algorithm and Second Parallel Algorithm (FPA and SPA). The architectural requirements, i.e., synchronization and communication mechanisms, for the implementation of these algorithms on a two-dimensional array of $n(n+1)/2$ processors are analyzed. It is shown that, while the FPA achieves a better computational complexity, the SPA requires a much simpler interconnection structure.

Mapping the FPA and SPA on a linear array of n processors with a nearest-neighbor interconnection results in two new algorithms designated as the First and the Second Architecture-Dependent Algorithm (FADA and SADA) with the computational complexity of $O(n\log_2 n)+O(\log_2 n)+O(1)$. It is shown that the FADA is more efficient than the SADA, which implies that the FPA is more suitable than the SPA for implementing on a linear array.

A Parallel/Pipeline Algorithm (PPA) is also

developed with computational complexity of $O(n)+O(\log_2 n)+O(1)$, which represents the fastest computation time for evaluating the inertia matrix on a one-dimensional linear array of n processors. Compared to the FPA which achieves the best computation time on a two-dimensional array of $n(n+1)/2$ processors, the PPA achieves a slightly smaller speedup but a significantly greater efficiency. Given this performance and the simple architectural requirements, the PPA represents an attractive alternative for exploiting concurrency in computing the inertia matrix. The computational costs of different algorithms are presented in the table where m and a represent the cost of multiplication and addition, respectively. ($\lceil x \rceil$ denotes the smallest integer greater than or equal to x; $x^* = x$ if $x = 2^m$, and $x^* = 2^m$ if $2^m > x > 2^{m-1}$.) The speedup and efficiency of different algorithms (for $n = 6$) are also evaluated and presented in the table. In this evaluation, the cost of multiplication and addition is taken to be the same.

ALGORITHM	COMPUTATION COST GENERAL	COMPUTATION COST $n = 6$	SPEEDUP	EFFICIENCY PERCENT
SA	$((9/2)n^2 + (231/2)n - 181)m + (4n^2 + 88n - 137)a$	$664m + 535a$	1	100
FPA	$(48m + 63a)\lceil \log_2 n \rceil + (100m + 65a)$	$246m + 255a$	2.40	12
SPA	$(54m + 69a)\lceil \log_2 n \rceil + (94m + 69a)$	$258m + 264a$	2.28	11
FADA	$(3a)n\lceil \log_2 n \rceil + (9m + 8a)n - (3a)n^* + (48m + 60a)\lceil \log_2 n \rceil + (64m + 42a)$	$258m + 295a$	2.13	36
SADA	$(6m + 9a)n\lceil \log_2 n \rceil + (3m + 2a)n - (6m + 9a)n^* + (48m + 60a)\lceil \log_2 n \rceil + (70m + 48a)$	$294m + 331a$	1.93	32
PPA	$(9m + 8a)n + (48m + 63a)\lceil \log_2 n \rceil + (58m + 24a)$	$261m + 273a$	2.32	39

Comparison of Serial, Parallel, and Parallel/Pipeline Algorithms is shown for quick reference. Here SA is Serial Algorithm; FPA is First Parallel Algorithm; SPA is Second Parallel Algorithm; FADA is First Architecture-Dependent Algorithm; SADA is Second Architecture Dependent Algorithm; and PPA is Parallel/Pipeline Algorithm.

This work was done by Amir Fijany and Antal K. Bejczy of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 92 on the TSP Request Card.*
NPO-17718

Transfer Functions via Laplace- and Fourier-Borel Transforms

A new approach could simplify the solution of nonlinear differential equations.

Ames Research Center, Moffett Field, California

An approach to the solution of nonlinear ordinary differential equations involves transfer functions that are based on the recently-introduced Laplace-Borel and Fourier-Borel transforms. In general, the solutions to such equations are represented by nonlinear functional expansions that are analogous to Fourier-series or Fourier-integral expansions of the response functions of linear systems. These nonlinear functional expansions can be summarized by the new transforms, so that the responses of nonlinear dynamical systems can be expressed in terms of transfer functions that are analogous to those of linear systems.

The Laplace-Borel (LB) and Fourier-Borel (FB) transforms of the function $f(t)$ are given by

$$LB[f(t)] = F(x_0) = x_0^{-1}\int_0^{\infty} e^{-t/x_0} f(t)dt$$

and

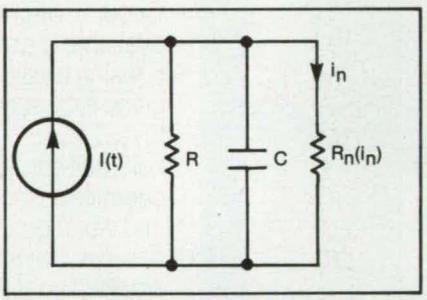
$$FB[f(t)] = F(j\beta) = j\beta\int_{-\infty}^{\infty} e^{-j\beta t} f(t)dt$$

respectively.

The Laplace-Borel transforms can also be summarized as operators that one can obtain from the Laplace transforms $F(s)$ as follows:

$$|sF(s)|_{s = x_0^{-1}}$$

except that the algebra on the noncommutative variable x_0 is richer. In addition to the Cauchy product, there is the shuffle product, which provides the mechanism to take care of the nonlinear terms. The connection between the Laplace and Fourier transforms is analogous to that between the Laplace-Borel and Fourier-Borel transforms. One can generalize the Laplace-Borel transforms to Fourier-Borel transforms in the same way that Fourier transforms are generalized from Laplace transforms.



The **Laplace-Borel Transfer-Function Approach** can be used to analyze the response of this circuit to the input current $I(t)$ (where t = time). The equations that describe the behavior of the circuit are nonlinear because the resistance R_n varies with the current i_n flowing through it.

The main theorem of the new approach gives the transform of the response of a nonlinear system as a Cauchy product of its transfer function and the transform of the input function of the system, together with memory effects. First, the transfer function, G, of the system is obtained from the Laplace-Borel transform of the nonlinear differential equation of the system. Next, the Laplace-Borel transform is taken of the input function plus initial conditions of the response plus the higher-order derivatives of the initial response. Then the Laplace-Borel transform of the response of the system is the Cauchy product of the two foregoing transforms.

The new approach can be used, for example, to determine the responses of electrical circuits that contain variable inductances or resistances (see figure). One attractive feature of this approach is the possibility of doing all of the noncommutative algebra on computers in such symbolic programming languages as Macsyma, Reduce, PL1, or Lisp. The process of solution could be organized and possibly simplified by algebraic manipulations that reduce the integrals in the solutions to known or tabulated forms.

This work was done by Sumer Can, graduate student at Santa Clara University, and Aynur Unal of **Ames Research Center**. *Further information may be found in NASA TM-100034 [N90-10828], "Transfer Functions for Nonlinear Systems via Fourier-Borel Transforms."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700. ARC-12295

Life Sciences

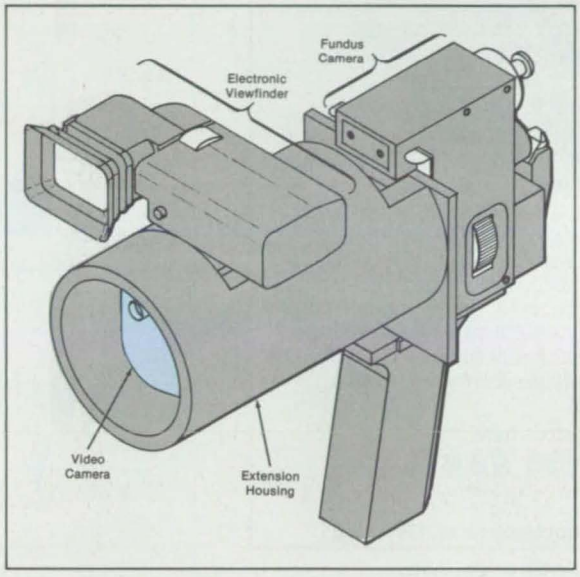
Hardware, Techniques, and Processes

Portable Video/Digital Retinal Funduscope

An inexpensive instrument can be operated with minimal training, under hospital or field conditions.

Lyndon B. Johnson Space Center, Houston, Texas

A lightweight, relatively inexpensive electronic and photographic instrument has been developed for the detection, monitoring, and objective quantification of ocular/systemic disease or physiological alterations of the retina, blood vessels, or other structures in the anterior and posterior chambers of the eye. The instrument can be operated with little training. It can function with a human or animal subject seated, recumbent, inverted, or in almost any other orientation; and in a hospital, laboratory, field, or other environment. The instrument produces video images that can be viewed directly and/or digitized for simultaneous or subsequent analysis. It can also be equipped to produce photographs and/or fitted with adaptors to produce stereoscopic or magnified images of the skin, nose, ear, throat, or mouth to detect lesions or diseases.



The **Portable Funduscope** has a modular design. The extension housing, video camera, and electronic viewfinder can be removed and replaced with a 35-mm film camera. The fundus camera can be equipped with a variety of lenses, prisms, and the like.

The instrument is an assembly of commercially available equipment, some of which has been modified slightly to make it compatible with the other equipment and the overall design. One major component is a portable fundus camera with lenses, filters, and prisms as required for various viewing configurations. The image produced by the fundus camera is either recorded on 35-mm film or sensed by a low-light-level charge-coupled-device (CCD) video camera (see figure). The other major components are an electronic viewfinder, a video monitor for viewing in real time, and a computer that digitizes the video image.

Equipment to stabilize the subject's head is included, but the instrument can be operated without such stabilization. The operator can adjust the focus on the fundus camera while viewing through an eyepiece, using either the 35-mm-film-camera attachment or looking directly at the electronic viewfinder mounted on the CCD camera. When the desired image is obtained, the camera is secured in place. Excitation and barrier filters can be inserted into the fundus camera for fluorescein angiography. The images from the CCD camera can be directly digitized by the computer for storage or transferred via telephone lines, computer networks, or satellite to remote locations.

By providing for the digital analysis of images, the instrument helps physicians to compare sequential images from a given patient to detect subtle disease progressions earlier. In addition, the acquisition of images as digital information facilitates storage, transfer, and manipulation to enhance features of interest. It also enables extensive analyses of images, including quantitative analyses of the diameters of blood vessels and the detection and monitoring of changes in retinas caused by hypertension, diabetes, atherosclerosis, vasculitis, uveitis, macular degeneration, glaucoma, and infections. The instrument can be upgraded easily as advanced sources of light, optical equipment, CCD cameras, computers, and image-analyzing computer programs become available.

This work was done by Gerald R. Taylor of **Johnson Space Center**; *Richard Meehan of the University of Colorado; and Norwood Hunter, Michael Caputo, and C. Robert Gibson of Krug International. For further information, Circle 37 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center [see page 16]. Refer to MSC-21675.

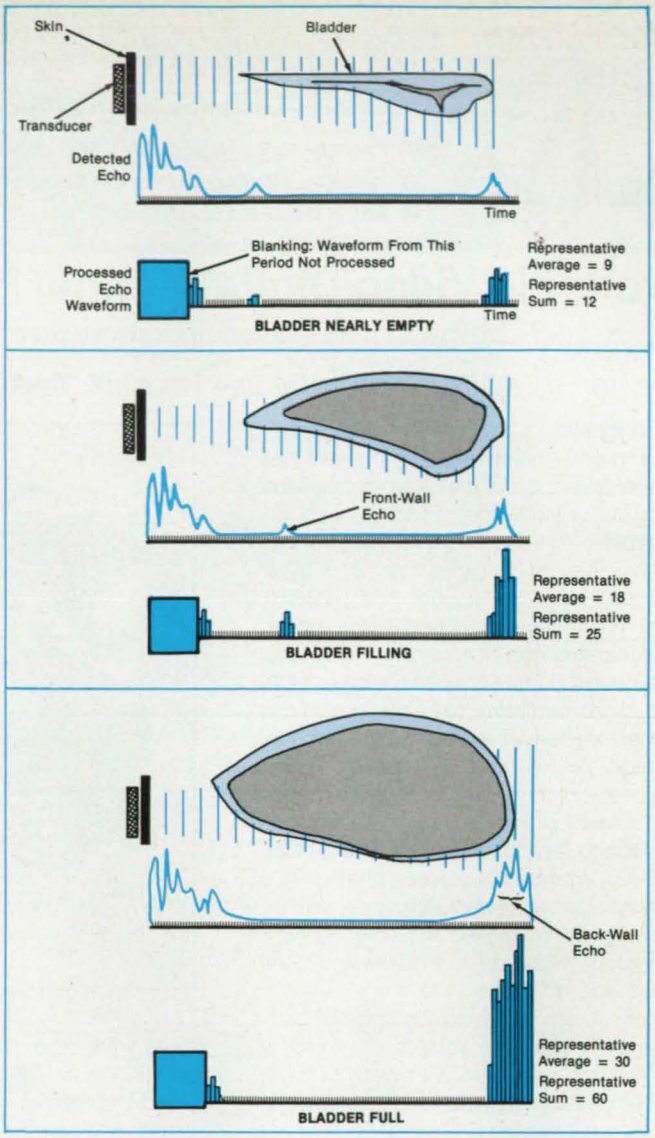
Ultrasonic Device Monitors Fullness of the Bladder

A self-contained, portable, battery-powered unit is specifically tailored for each patient.

Langley Research Center, Hampton, Virginia

An ultrasonic device that monitors the fullness of the bladder is self-contained, lightweight, portable, powered by a battery, and tailored for the specific patient through software that can be modified as the patient's behavior changes. The monitor essentially quantifies the amount of urine in the bladder by measuring the relative distension of the bladder and then gives a suitable alarm that tells the patient to eliminate. The device is intended for use in training people who are incontinent and cannot identify when elimination is necessary.

Previous bladder sensors fall into two



Ultrasonic Echoes are processed to detect characteristic echo waveforms that signify distension of the bladder.

classes: simple and elaborate. The simple category includes the wetness detector, which alarms the patient when urine is present. The wetness detector provides an alarm after the fact and has not proven to be very effective as a training aid. It can also be mistriggered by sweat. The second class of sensors includes the clinical ultrasonic scanner. Such an instrument requires considerable expertise to operate and is too bulky and expensive to serve as a personal training aid. All of the previous bladder sensors lack the adaptability to cope with the problems of ambulatory and widely variable patients.

The present monitor is also based on ultrasonics but processes the data in a different way to achieve the desired results. It includes a digital electronic system that tracks the trends of three different parameters, analyzes signatures, and computes a weighted sum to produce a numerical value that characterizes the relative distension of the bladder. Once that value has been derived, it can be compared to an alarm value, selected by the user, that signifies fullness and at which the device indicates the need to void. The activity of the bladder and personal habits of the individual are used to customize the software and the ultrasonic sensor to that individual. All of the control functions are made adjustable by the user or caregiver to enable optimization.

The monitor includes an ultrasonic transducer that is excited by a pulser/receiver under the command of digital logic circuitry. An acoustic wave of low power and frequency is

launched into the abdominal area of the patient. The wave interacts with the wall of the bladder, is reflected back to the transducer, and is then amplified and detected by the receiver. The resulting signal is digitized and stored.

These signals are averaged in groups over time, and the trend of the sums is taken to be an indication of the distension of the bladder. Various alarms are available, depending on the preference of the user. The electronics package includes circuitry that can alert the patient with a variety of stimuli including tactile output (vibrator), visual output (light-emitting diode mounted on eyeglasses), and audible output (earphone or buzzer). The monitor can also transmit a radio-frequency output to a remote receiver monitor.

The operation of the monitor is shown in the figure, which is split into three sections: bladder nearly empty, bladder filling, and bladder full. Each section shows a simplified diagram of the bladder at the top, the resulting waveform of the acoustical echo in the middle, and the digitally processed and weighted waveforms at the bottom. As the bladder fills, the returning echoes display a characteristic pattern of movement and change. The processing accentuates the pattern as it relates to the filling of the bladder. Once this has been done, the energy content of each scan of 128 readings is summed into a single numerical value, and this value is used to indicate the distension of the bladder.

Because this monitor is not designed to form an image of the bladder, it is much smaller and far less complicated and expensive than commercially available ultrasound scanners are. The entire electronics package is worn by the patient with the transducer in a flexible, nonobtrusive belt. Inasmuch as this monitor includes a microcomputer, it is "smart" enough to extract only the useful information from the ultrasonic echos. Because the monitor has built-in features that provide a large number of selectable variables, it can be customized to the individual user more easily than any previously available bladder monitor could be. The device turns itself off between readings to prolong the life of the battery.

This work was done by Joseph S. Heyman and Travis Blalock of **Langley Research Center**, *John A. Companion of PRC Kentron, and Al Cavalier and Beth A. Mineo of the Association for Retarded Citizens. No further documentation is available.*

This invention has been patented by NASA (U.S. Patent No. 4,852,578). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center [see page 16]. Refer to LAR-13689.

Computer-Driven Keratometer

A simple optical system would measure corneal deformations.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed instrument would measure deformations of the surface of the cornea. The keratometer would assist in the rapid diagnosis of eye ailments and preparation of the cornea for surgery. Unlike instruments now available, the proposed unit would not require critical alignment with the eye; its results would therefore be more reliable, and it would be easier to use.

Through a lens-and-reticle system, the instrument would project a series of rings on the subject's eye and capture the reflected rings with a video camera (see figure). It would superimpose a computer-stored reference image (of how the reflection of the reticle from a correctly shaped version of the cornea should look) on the actual image reflected from the subject's eye. In the absence of deformation of the cornea, the rings of the real and reference images would coincide. If the cornea were deformed, some or all of the rings would be displaced. The computer would analyze the displacement to determine the amount of deformation and would control a display of the shape of the cornea.

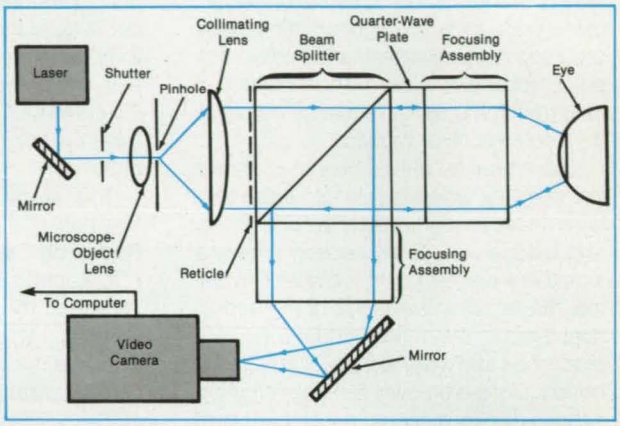
The optical portion of the proposed instrument would differ from that of standard keratometers by having only one reticle instead of two. Therefore, the optical system would be much simpler. In addition, the operator would not have to align the images manually: the computer would determine the center of the reflected ring pattern and would place the center of the reference ring pattern on it. Fringes from misalignment—a substantial problem with standard keratometers—would be avoided; only those resulting from deformation would appear.

This work was done by Edmund C. Baroth of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 96 on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

Edward Ansell
Director of Patents and Licensing
Mail Stop 305-6
California Institute of Technology
1201 East California Boulevard
Pasadena, CA 91125

Refer to NPO-17079, volume and number of this NASA Tech Briefs *issue, and the page number.*



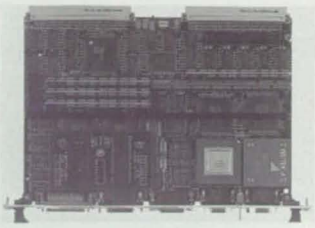
A shuttered laser would briefly **Illuminate the Subject's Eye** through a reticle, thereby projecting concentric rings of light on the eye. Reflected by a beam splitter and mirror into a solid-state video camera, the ring pattern would be compared with a reference pattern by a computer. The laser would probably be of a helium/cadmium type with blue output.

New on the Market

Elexor Associates Inc., Morris Plains, NJ, has introduced the LB-386, a **portable data acquisition system** that offers acquisition rates up to 100,000 samples per second. With full expansion, up to 128 analog and 112 digital channels can be simultaneously scanned. The system's software supports Fourier analysis, auto-scaling, and statistical analysis, as well as all common math functions.
Circle Reader Action Number 798.

Galactic Industries Corp., Salem, NH, has released version 2.22 of its Lab Calc **chromatography software**, which enables fast quantitative evaluation of chromatographic samples. A new method editor provides powerful method commands including flexible baseline override commands, forced peaks, negative peaks, and advanced auto injector control without operator intervention. Advanced baseline correction can subtract complex polynomial baselines from data, and raw chromatograms can be adjusted for run-to-run retention time differences.
Circle Reader Action Number 776.

The TDS 500 series of **digitizing oscilloscopes** built by Tektronix Inc., Beaverton, OR, incorporates an intuitive graphical interface, high-speed acquisition system, advanced triggering, and multiprocessor power. The scopes offer variable record lengths of up to 50,000 points per channel, 8-bit vertical resolution, 4 ns glitch capture, and 1% accuracy. On-board digital signal processing functions include waveform pass/fail testing, fast signal averaging, and waveform math.
Circle Reader Action Number 786.



A 16-megabyte version of the SPARC CPU-1E **VME single-board computer** has been introduced by Force Computers Inc., Campbell, CA, bringing the power and software compatibility of a Sun workstation running SunOS to the embedded systems market. The CPU-1E/16 complements the current SPARC CPU-1E 4-MB product.
Circle Reader Action Number 774.

The MCB-4 **stepping motor controller/driver board** from Advanced Control Systems Corp., Hingham, MA, can simultaneously control four four-phase stepping motors. The board, which can serve as an independent controller or be controlled by a host computer via a serial port, provides stepping rates up to 10,000 steps per second, with 16.7 million steps per move.
Circle Reader Action Number 780.

Aremco Products Inc., Ossining, NY, has introduced Ceramabond™ 671, an **alumina-ceramic-based adhesive** with temperature endurance to 1760° C. Resistant to vibration, corrosion, and oxidation, the single-component adhesive is ideal for industrial and aerospace thread locking applications.
Circle Reader Action Number 790.

VMETRO, Houston, TX, has introduced an SCSI-equipped **VMEbus tracer** that enables engineers to create massive real-time audit trails of VMEbus traffic on disk. The audit trails, consisting of potentially millions of bus transactions, are stored in a UNIX-compatible file format. Applications include recording and playing back system test scenarios, analysis and monitoring of real-time systems and computer security mechanisms, and isolation of data-driven bugs in large programs.
Circle Reader Action Number 784.

MSC/DYTRAN™, a new computer program for **analysis of high-speed fluid-structure interaction,** is available from the MacNeal-Schwendler Corp., Los Angeles, CA. The program is designed for analysis of short-lived events involving the interaction of fluids and structures, and problems involving extreme deformation of materials. Typical applications include analyzing the inflation and unfolding of airbags, and chemical and nuclear plant safety studies.
Circle Reader Action Number 782.

A versatile **scan converter** offered by James Grunder & Assoc. Inc., Mission, KS, converts graphics or text into broadcast-quality NTSC or PAL TV standards. Its unique 16-step flicker elimination circuitry ensures a sharp, flicker-free picture. Standard features include a zoom function, broadcast color encoder, sync generator, RS232 serial port for full remote control, and adjustable picture height and width for aspect ratio correction.
Circle Reader Action Number 796.

A new line of **pen plotters** from Houston Instrument, Austin, TX, combines expanded memory capabilities, plot file compression, and faster data transmission rates to significantly reduce the time a computer takes to send a drawing file to the plotter and then become available again for other work. The DMP-160 series plotters support the HP-GL/2 plot language and offer 512 K standard memory with optional expansions to 1, 2.5, or 4 MB.
Circle Reader Action Number 794.

Electrim Corp., Princeton, NJ, has released a solid-state **electronic imager** that enables direct digitization of images at up to 754 x 488 pixels. The EDC-1000HR monochrome camera is compatible with an IBM PC/XT/AT or equivalent and features high blue response, low dark current, wide dynamic range, antiblooming, pixel geometric fidelity, and computer-controlled subarray scanning.
Circle Reader Action Number 788.

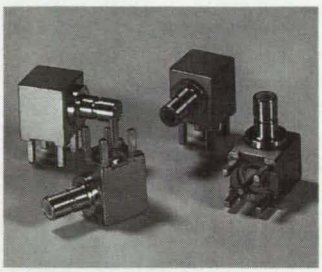
Drystar® CDP **dry pumps** from Edwards High Vacuum Intl., Wilmington, MA, provide reliable vacuum pumping in clean, particulate producing, and corrosive environments. They feature innovative nitrogen-gas-packed shaft seals, indirect cooling systems, and enhanced exhaust management. Applications include load lock chambers, sputtering and evaporation systems, film deposition, photoresist stripping, and ion implantation.
Circle Reader Action Number 778.

Spiral Software, Brookline, MA, has announced version 2.1 of EasyPlot, an IBM PC-compatible **software program** that enables engineers and scientists to view and manipulate large sets of numbers graphically. The update offers expanded memory support to handle more than 100,000 points and a windowing system to manage multiple graphs. Other new features include text-based and graphical editors, an enhanced curve-fitting algorithm, dual axes, bar charts, and 3D scatter plots that rotate in real time.
Circle Reader Action Number 792.

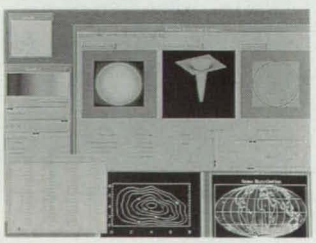
The first **chip set** designed specifically for the new Futurebus+ high-performance computer bus standard is available from National Semiconductor Corp., Santa Clara, CA. Futurebus+ is an open-architecture scheme that brings higher bandwidths to data communications within workstations, high-end PCs, mid-range computers, and larger systems. The new chip set includes a 9-bit data transceiver in latched and unlatched versions, a handshake transceiver, a 9-bit distributed arbitration transceiver, and an arbitration controller.
Circle Reader Action Number 800.

New on the Market

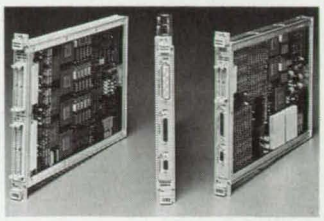
Dolch Computer Systems, Milpitas, CA, has introduced a 20 MHz 386SX **portable computer** that includes a 16 MB system DRAM, 64 KB cache SRAM, and five uncommitted, full-size ISA slots. The Dolch PAC SX-20C features a bright red gas plasma display with 16 shades of gray scale at 640 x 480 VGA resolution. For a full-color, CRT-like display, Dolch offers an active matrix thin-film transistor LCD flat panel that has a palette of 24,389 colors.
Circle Reader Action Number 754.



A new **pressure-sealed coaxial connector** for printed circuit boards saves production time and eliminates possible causes of connector failure. Developed by ITT Cannon/Sealectro, New Britain, CT, the connector can be immediately transferred from wave soldering to the cleaning bath without fear of contamination, because pressure-sealing prevents cleaning fluid from entering the connector cavity.
Circle Reader Action Number 746.

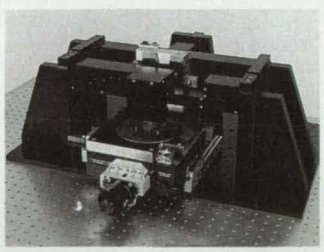


Research Systems Inc., Boulder, CO, has released IDL/maps for **visually analyzing remote sensing data** on workstations. The program displays maps using ten standard mapping projections and overlays images in latitude/longitude coordinate systems using irregular data gridding techniques. It can zoom, rotate, find inverses, and plot data using contours or text. IDL/maps has applications in the atmospheric and oceanic sciences, space research, hydrology, and related fields.
Circle Reader Action Number 752.



A high-precision **timing generator** developed by Racal-Dana Instruments Inc., Irvine, CA, provides 5-nanosecond timing resolution over a 5 kHz to 20 MHz frequency range. The model 6459 permits high-speed dynamic digital testing and use of a digital probe. It generates up to eight timing strobes for digital test modules on the VXIbus.
Circle Reader Action Number 756.

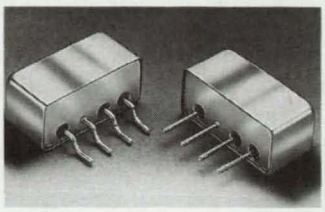
Seiko Instruments USA Inc., Torrance, CA, has introduced the SEA2001 **x-ray fluorescence element analyzer**, a desktop system for determining the elemental composition of solids, powders, and liquids. The SEA2001 automatically and nondestructively tests up to 12 samples without operator interference. It can detect more than 80 elements, from sodium through uranium on the periodic table.
Circle Reader Action Number 770.



Digital Instruments, Santa Barbara, CA, is offering a **scanning probe microscope** able to accommodate samples as large as 8" in diameter. The scope images surfaces with 3D nanometer resolution, using either scanning tunneling or atomic force microscopy. X-Y stage positioning can be controlled manually or automatically and is accurate to within ±10 microns.
Circle Reader Action Number 764.

Coreco, St-Laurent, PQ, has introduced the OCULUS-300, a low-cost **frame grabber** with add-on features that turn it into a powerful image processing engine. The OCULUS-300 is expanded with a DILUT processor, a memory expansion module, an expansion piggyback for true color imaging, and a run-length encoding processor.
Circle Reader Action Number 762.

CADAM Inc., Burbank, CA, has released a new version of P-CAD Master Designer™, a **software package for printed-circuit board design**. Version 5.0 features extended DOS memory to handle large designs and to provide room for local area network (LAN) designs. Other enhancements include user-configurable menus, real-time on-line design rule checking, and parts editing.
Circle Reader Action Number 768.



With all-welded construction, the new TUF Ultra-Rel™ **mixers** from Mini-Circuits, Brooklyn, NY, can withstand 250° C for five minutes with no performance degradation. The units can survive the extreme shock and vibration stresses of MIL-STD-28837, as well as more than 200 cycles of thermal shock ranging from -55° to +100° C. They are available for surface-mounting or plug-in applications.
Circle Reader Action Number 760.

A new **electronic memory (EM) motion analyzer** from Eastman Kodak Co., Rochester, NY, can record up to 12,000 split-frame images per second. The model 1012 has a "semi-smart" reference reticle for quantitative analysis. Targeted for quality assurance, R&D, and product design applications, it can integrate analog and switch data with images, and will automatically download video pictures to a VCR.
Circle Reader Action Number 766.

The ELCOM® line of high-performance **brushless servo motors** from Pittman, Harleysville, PA, incorporates unique stator designs that contribute no magnetic cogging and result in low winding inductances and electrical time constants. A new six-pole model features a samarium cobalt rotor construction for high torque-to-inertia ratios and resistance to demagnetization.
Circle Reader Action Number 758.

A new **color video printer** combines high resolution with large print size, a 16.7 million color palette, and fine-tuning capability to accommodate various input sources. Developed by Mitsubishi Electronics America, Somerset, NJ, the CP-210U printer employs a sublimation dye thermal transfer process and high-density paper, enabling output of endoscopic, color-flow Doppler and computer graphics. The printer automatically adjusts to any input source and can print four independent images on a single sheet for time-lapse evaluation. It also features full-frame RGB memory, automatic gain control, and wired remote control.
Circle Reader Action Number 750.

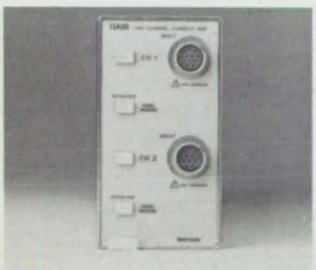
The new 8240 series color **CCD cameras** from Cohu Inc., San Diego, CA, are sealed and pressurized, and can withstand extremes of temperature, altitude, humidity, corrosion, dust, and shock. Designed for installation outdoors or in harsh environments, the cameras provide 460 TV lines of horizontal resolution and sensitivity of 1.1 lux. They also feature a 1/2" interline transfer imager with high signal-to-noise ratio, color lock, 1000:1 overload capability, and 20 dB AGC with peak/average adjustment.
Circle Reader Action Number 772.

A **PC program offering magnetic field capabilities** has been introduced by Swanson Analysis Systems Inc., Houston, PA. Called PC/MAGNETIC, the software is suited for analysis and design of electromagnetic equipment such as transformers, motors, transmission lines, actuators, and levitators. It permits 2D and 3D analyses, and includes DC, AC, and transient magnetic field capabilities for linear and nonlinear materials.
Circle Reader Action Number 748.

New on the Market

Sparcom Corp., Corvallis, OR, has introduced the Portable Professional FD-1000, a **battery-operated disk drive** for the HP 48 series of programmable scientific calculators. The drive delivers 15 hours of remote operation on a single charge, reads and writes in PC-DOS on 3.5" disks, and supports 720 KB and 1.44 MB capacity disks. It uses an embedded Kermit file transfer protocol that allows data transfer between completely different machines, such as between an HP calculator and a UNIX workstation.
Circle Reader Action Number 795.

A fully-programmable, echo-type **ultrasonic sensor** has been developed by the Electronic Design and Packaging Co., Livonia, MI. Calibrated using a PC, the SonaSwitch 2000 allows users to select from ten operating frequencies, with variable transmission pulse count. Sample rates, relay set points, and 0-5 v/4-20 mA outputs are calibrated in software or by using multiturn potentiometers.
Circle Reader Action Number 793.



Pictured above is a new **current amplifier** from Tektronix Inc., Beaverton, OR, that enables users to make direct measurements on current waveforms. Designated the 11A16, it provides automatic timing deskew and amplitude calibration. Combined with the Tektronix 11000 series digital oscilloscopes or DSA 600 signal analyzers, the 11A16 offers a versatile current analysis and measurement system for such applications as testing power supplies, motion control and servo systems, and high-frequency power conversion.
Circle Reader Action Number 791.

Loctite Luminescent Systems, Lebanon, NH, has developed a phosphor that triples the useful life of **electroluminescent lamps** and provides higher levels of sustainable brightness. Lamps with the Aurora phosphor operate for 20,000 hours to 5 fL at 115 v, 400 Hz. By comparison, industry-standard EL lamps typically last about 7000 hours to 5 fL. The improved lamps are suited for LCD displays used in laptop computers, word processors, and medical instrumentation.
Circle Reader Action Number 789.

On-Board® **cryopump systems** from CTI-Cryogenics, Waltham, MA, allow for remote control and monitoring, thereby reducing process contamination and increasing operational efficiency. They feature fast, thorough on-board regeneration as well as advanced diagnostics that record pump performance over time, permitting early detection of degradation tendencies. Cryopumping is controlled by a host computer, via an RS-232 interface, or a pump-mounted or remote keypad/display.
Circle Reader Action Number 797.

Verbatim Corp., Charlotte, NC, is distributing 3.5" rewritable and O-ROM (optical read only memory) **optical disks** that are fully operational in the new IBM 3.5" optical drive and all other 3.5" ISO standard drives. Portable and securable, the disks provide fast access to data, making them ideal for on-line applications such as document management. Further, they are resistant to head crashes, moisture, pollution, and extreme temperatures.
Circle Reader Action Number 799.

A new **design automation software tool** created by EEsof Inc., Westlake Village, CA, is the first integrated CAE/CAD suite developed specifically for design of RF circuits operating at 3000 MHz and below. Called jOMEGA, it combines a harmonic-balance linear/nonlinear circuit simulator with an advanced graphics package that provides schematic entry, multi-window simulation control, engineering documentation, and RF board design layout and floor planning.
Circle Reader Action Number 787.

New Literature

Dynacast Inc., Yorktown Heights, NY, has released literature on the fabrication of zinc, aluminum, and magnesium **precision die cast components**. Data sheets explain the materials' specifications and their applications in electronics, transportation, and design.
Circle Reader Action Number 720.

Modern Manufacturing Processes, published by Industrial Press, New York City, details 28 **advanced manufacturing processes and materials**, including metal injection molding, abrasive waterjet cutting, hydroforming, computer-integrated manufacturing, ultrasonics, electrochemical machining, and hot isostatic pressing. The 256-page sourcebook compares the costs, advantages, and applications of nontraditional and standard manufacturing methods.
Circle Reader Action Number 708.

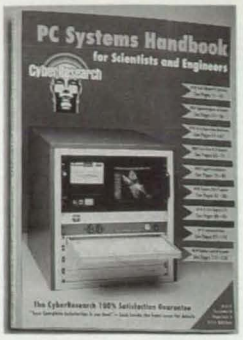
Crouse-Hinds Molded Products, Syracuse, NY, has published a 24-page catalog of its Mini-Line and Micro-Mini **connectors**. The four-color catalog describes the advantages of softwiring over hardwiring and cites applications for Crouse-Hinds' quick-disconnect products in heavy process industries. Featured products and accessories include Mini-Line with indicating lights and high-flex SOOW-A cable; liquid-tight plugs; corrosion-resistant cord grips; and panel-mount receptacles.
Circle Reader Action Number 716.

A free brochure highlights applications for iron-, nickel-, and cobalt-based **amorphous alloys** developed by Metglas Products, Parsippany, NJ. The patented alloys are strong, flexible, corrosion-resistant, and, because of their random amorphous atomic structure, easy to magnetize and anneal. They are suited for use in electromagnetic shielding, lamp ballasts, motors, pulse power systems, recording heads, and transducers.
Circle Reader Action Number 712.

A 40-page catalog from Sprague, Hudson, NH, details **thick-film networks** in molded and conformally-coated SIP, DIP, and surface mount packages. These products are designed for use in computer memory and logic systems, computer peripherals, telecommunications systems, automobiles, test instruments, A/D and D/A converters, and any electronic circuit or application where repetitive resistor, capacitor, or resistor-capacitor configurations are required.
Circle Reader Action Number 718.

High-power laser diodes are showcased in a new brochure from Ensign Bickford Aerospace, Simsbury, CT. Included are the EBAC-140E series, which incorporates thermoelectric cooling with closed loop temperature control for wavelength tunability, and the EBAC-140A series of compact diodes for applications such as proximity sensing and range finding. The full-color brochure also describes Ensign Bickford's state-of-the-art manufacturing facility, optimized for production of semiconductor lasers and arrays of one watt and above.
Circle Reader Action Number 726.

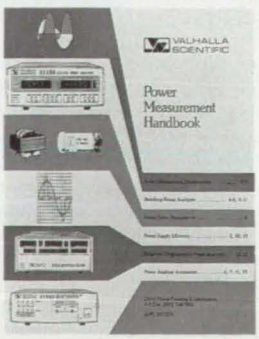
AT&T, Warren, NJ, has released a catalog of **licensable software** developed by the company to solve problems, reduce costs, and optimize business operations. Entitled *Software Driven Solutions*, the 44-page catalog describes such programs as MetaTool, which expedites software tool building in the UNIX system environment; Graphical Expert System Creation Tool, which builds circuit-pack diagnostic expert systems; Record Control System II, a multi-user engineering document management system that can support over one million records; and Operations Assistant Software, an interactive resource management tool for optimizing factory operation. Many of the software packages are available to third-party vendors for sublicensing.
Circle Reader Action Number 728.



A new **PC systems** handbook from CyberResearch Inc., Branford, CT, features a large selection of rack-mount PCs and peripherals, rack-mount IBM-compatible PCs with built-in VGA monitors, remote data acquisition equipment, signal analysis software, and motion control products. *Tech Notes* sprinkled throughout the book discuss topics such as "The Nyquist Frequency," "Cold-Junction Compensation," "Stepping Motor Theory," and "Alternative Serial Communications Standards."
Circle Reader Action Number 724.

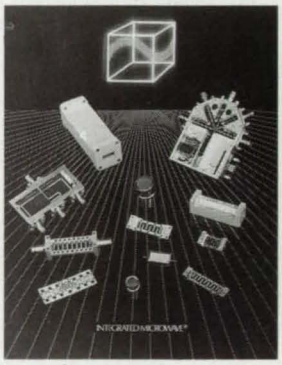
Optical Research Associates, Pasadena, CA, has produced a brochure highlighting its CODE V® **optical design and analysis software**, used to model, analyze, and support manufacturing of laser scanners, simulators, holographic displays, and other optical systems. Features include zoom/multi-configuration optimization, environmental analysis, MTF and RMS wavefront-based tolerancing, and holographic optical element modeling. CODE V runs on DEC VAX or Sun SPARCstation computers.
Circle Reader Action Number 722.

A **digital power analyzer** handbook offered by Valhalla Scientific, San Diego, CA, covers power fundamentals, power factor, true RMS AC/DC current and voltage measurements, and more. The 16-page handbook features single- and three-phase digital wattmeters and power factor meters for testing switching power supplies, electric motors, transformer-incorporated products, ballasts, and appliances.
Circle Reader Action Number 704.



A 500-page **microelectronics** catalog from Terra Universal Inc., Anaheim, CA, describes manufacturing and testing products for the semiconductor industry, and features articles on 30 technical subjects, including atmosphere and static control, extending shelflife, and SMIF.
Circle Reader Action Number 710.

IBM's new **POWER Visualization System** is explained in a full-color, fold-out brochure. The system, which incorporates the RISC System/6000, converts large amounts of supercomputer data into high-resolution pictures that can be rapidly analyzed, manipulated, and explored. It supports up to one gigabyte of shared memory and can calculate images at a peak rate of 2.5 billion floating-point operations per second. Features include parallel processing, high-speed communication links, parallel array disk drives, and high-definition television display support.
Circle Reader Action Number 714.

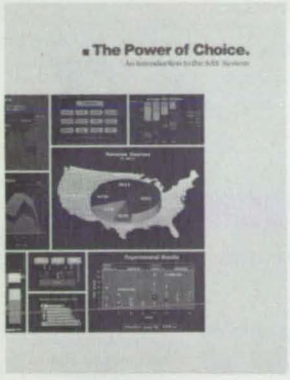


A 65-page catalog from Integrated Microwave, San Diego, CA, features **IF/RF/microwave filters** and integrated multifunction modules for aerospace, defense, and communications applications. The publication describes the performance of various product technologies, including miniature lumped element, miniature helical, suspended substrate, waveguide, interdigital, tunable, cavity, and switched filter banks. The company's computer-aided engineering services are also highlighted.
Circle Reader Action Number 706.

A full-color brochure from Schenck Pegasus Corp., Troy, MI, spotlights the L-CAT **laboratory computer-aided test controller,** designed for command signal generation, test monitoring, graphic signal analyzing, and data acquisition. The PC-based, network-compatible system has mechanical test applications in the aerospace, railroad, and automotive industries. It can be used for reliability testing or to evaluate structural fatigue properties.
Circle Reader Action Number 702.

New Literature

A fold-out brochure from Applied Dynamics International, Ann Arbor, MI, introduces the Real-Time Station, a VME-based computer system for **hardware-in-the-loop dynamic simulation**. It features a graphical user interface, highly-interactive run-time control, real-time graphics, and the ADSIM mathematical simulation programming language. The system communicates with remote locations in realtime and supports a wide range of high-level programming languages.
Circle Reader Action Number 740.



A four-color brochure discusses the SAS System, an **integrated software suite** for data access, management, analysis, and presentation. Developed by the SAS Institute Inc., Cary, NC, the software provides such analytical capabilities as forecasting, time series analysis, econometric modeling, and various statistical operations such as regression analysis, discriminant analysis, and linear modeling. Findings can be presented in bar and pie charts; line graphs; scatter, contour, and 3D plots; and choropleth, surface, block, and prism maps.
Circle Reader Action Number 732.

The 1991 engineering catalog from CADKEY Inc., Windsor, CT, describes over 300 **manufacturing and architectural software packages** for applications such as numerical control, finite element analysis, mold design, drafting, and prototyping. Featured products include CADKEY Version 4, a fully integrated 2D drafting and 3D design system; MOLDFLOW, which analyzes the injection molding of plastics; ARBOR SCAN, which converts engineering drawings into CADKEY; Advantage Details II, a CADD library of over 390 architectural details; and NWG World View, which realistically simulates complex environments.
Circle Reader Action Number 738.

STSC Inc., Rockville, MD, has published a brochure detailing STATGRAPHICS, a **statistical visualization software package** that integrates graphics with powerful statistical procedures for data analysis. It contains over 250 statistical and system procedures, covering such areas as variance analysis, experimental design, quality control, and exploratory data analysis, and features more than 50 graph types, including 2D and 3D line and scatterplots, bar and pie charts, 3D histograms, and time sequence plots. The menu-driven system offers import/export capabilities for ASCII, Lotus, DIF, and dBASE.
Circle Reader Action Number 734.

A 64-page **enclosures** catalog from Bopla Enclosures, Frederick, MD, lists the company's products for portable test instrumentation, computer-related test equipment and peripherals, handheld instruments, controls, monitor housings, and panel meters. Bopla's Polytan ABS plastic and polystyrene enclosures offer a lightweight alternative to metal enclosures.
Circle Reader Action Number 736.

Iotech's 1992 catalog highlights the Cleveland-based company's line of **data acquisition systems** and IEEE 488.2 bus controllers. The 130-page publication also covers interfaces and support products such as bus analyzers, extenders, and serial IEEE converters, and provides IEEE 488.2 and SCPI technical reviews.
Circle Reader Action Number 730.

Emcor Products, Rochester, MN, has published a four-color brochure describing its line of **modular enclosures**, including ESQ, 10 Series, Emcor 1, and EMI-RFI shielded cabinets. The publication also highlights cooling accessories and the CompuDesk® line of heavy-duty terminal workstations and single-unit assemblies.
Circle Reader Action Number 742.

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ADVERTISERS INDEX

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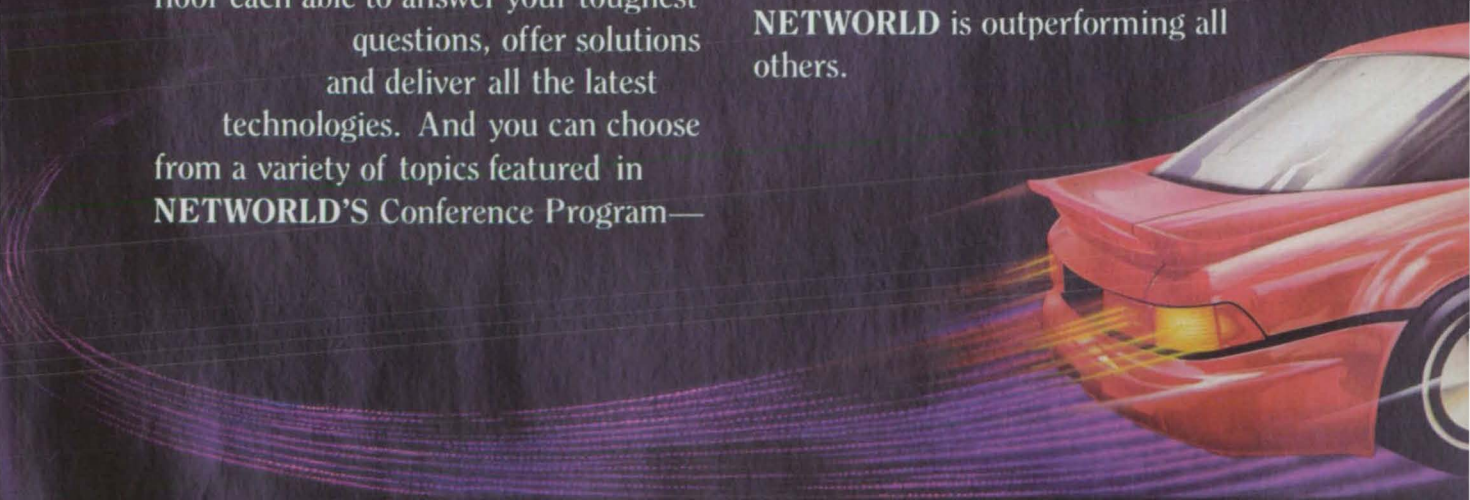

NETWORLD 91 DALLAS

October 15-17, 1991 Dallas Convention Center

NASA PATENTS

Over the past three decades, NASA has granted more than 1000 patent licenses in virtually every area of technology. Sales of licensed inventions exceed $10 million, and royalties paid to NASA approach $1 million. The Space Agency has a portfolio of 3000 domestic and foreign patents and pending applications available now for license by businesses and individuals, including these recently patented inventions:

Enhanced Single-Layer, Multi-Color Luminescent Display with Coactivators

(US Patent No. 4,987,339)

Inventor: **James Robertson**

Mr. Robertson has developed a multi-color flat-panel electroluminescent display offering improved flexibility and reliability. Its single-layer design reduces display weight, power consumption, and degradation characteristics. Colors, especially blue, are selectively enhanced by adding a coactivator to a colored activator without increasing the applied electric field.

Circle Reader Action Number 741.

Differential Current Source

(US Patent No. 5,021,729)

Inventor: **John F. Sutton**

A voltage-controlled current source employing operational amplifiers as active elements provides a symmetrical, differential, high-impedance drive to a load, with the drive isolated from any circuit common or system ground. The "floating" differential drive and identical source impedances of the two outputs eliminate errors from common mode voltages.

Circle Reader Action Number 753.

Airborne Rescue System

(US Patent No. 5,020,742)

Inventor: **Leonard A. Haslim**

Mr. Haslim has designed a lightweight telescoping rescue boom for helicopters. It enables the helicopter pilot to accurately position the rescue line while maintaining visual contact with the rescuee. For rescues at sea, the boom reduces exposure of the rescuee to downwash created by the main rotor. The invention's extension and retraction mechanism has many potential spinoff applications, including in-situ erection of telescopic space structures.

Circle Reader Action Number 749.

Etching Method for Photoresists or Polymers

(US Patent No. 5,007,983)

Inventors: **Narcinda Lerner** and **Theodore Wydeven**

Pattern development and substrate cleaning using organic photoresists are required at several steps in the fabrication of semiconductor devices. Consequently, the rapid removal of organic matter is necessary for efficient semiconductor manufacturing. The inventors have developed a new method that uses a sacrificial polymer to increase the rate of photoresist removal, cleaning, and polymer etching in downstream plasma reactors. In tests using polyethylene as a sacrificial polymer while stripping a commercial photoresist, the removal rate was 35 times greater than without the polymer.

Circle Reader Action Number 745.

Variable Magnification, Variable Dispersion Glancing Incidence Imaging X-Ray Spectroscopic Telescope

(US Patent No. 5,016,265)

Inventor: **Richard Hoover**

Mr. Hoover has created an x-ray spectroscopic telescope capable of high-spatial-resolution imaging of solar and stellar x-ray sources at precise spectral lines. Designed for use on the space shuttle or an orbiting space station, the telescope features a series of diffraction grating mirrors, reflecting different wavelengths, mounted on at least two rotatable carriers to obtain multiple magnifications and fields of view.

Circle Reader Action Number 747.

Rotationally-Actuated Prosthetic Helping Hand

(US Patent No. 5,021,065)

Inventors: **William Norton, Jewell Belcher, James Carden,** and **Thomas West**

A new prosthetic hand for below-the-elbow amputees is easy to operate, comfortable, and durable. It consists of a cuff, a stem, a housing, two hook-like fingers, an elastic band for holding the fingers together, and a brace. The fingers are pivotally-mounted on a housing that is secured to the amputee's upper arm with the brace. The stem is rotationally-mounted within the housing and secured to the cuff, which fits over the amputee's stump. By rotating the stem between the fingers with the lower arm, the amputee can open and close the fingers.

Circle Reader Action Number 751.

High-Pressure Promoted Combustion Chamber

(US Patent No. 4,990,312)

Inventors: **Michelle Rucker** and **Joel Stoltzfus**

A novel combustion chamber enables researchers to observe the burning behavior of polymers and metals at pressures up to 10,000 psi in various oxidizing environments. Several pressure-tight viewing ports, capable of withstanding the simulated environmental conditions, allow real-time analysis of the test sample. An ASTM Standard Test Method is being developed that uses this chamber.

Circle Reader Action Number 743.

For more information about the inventions described above, including licensing procedures, circle the corresponding number on the Reader Action Request Form (page 113). ❑

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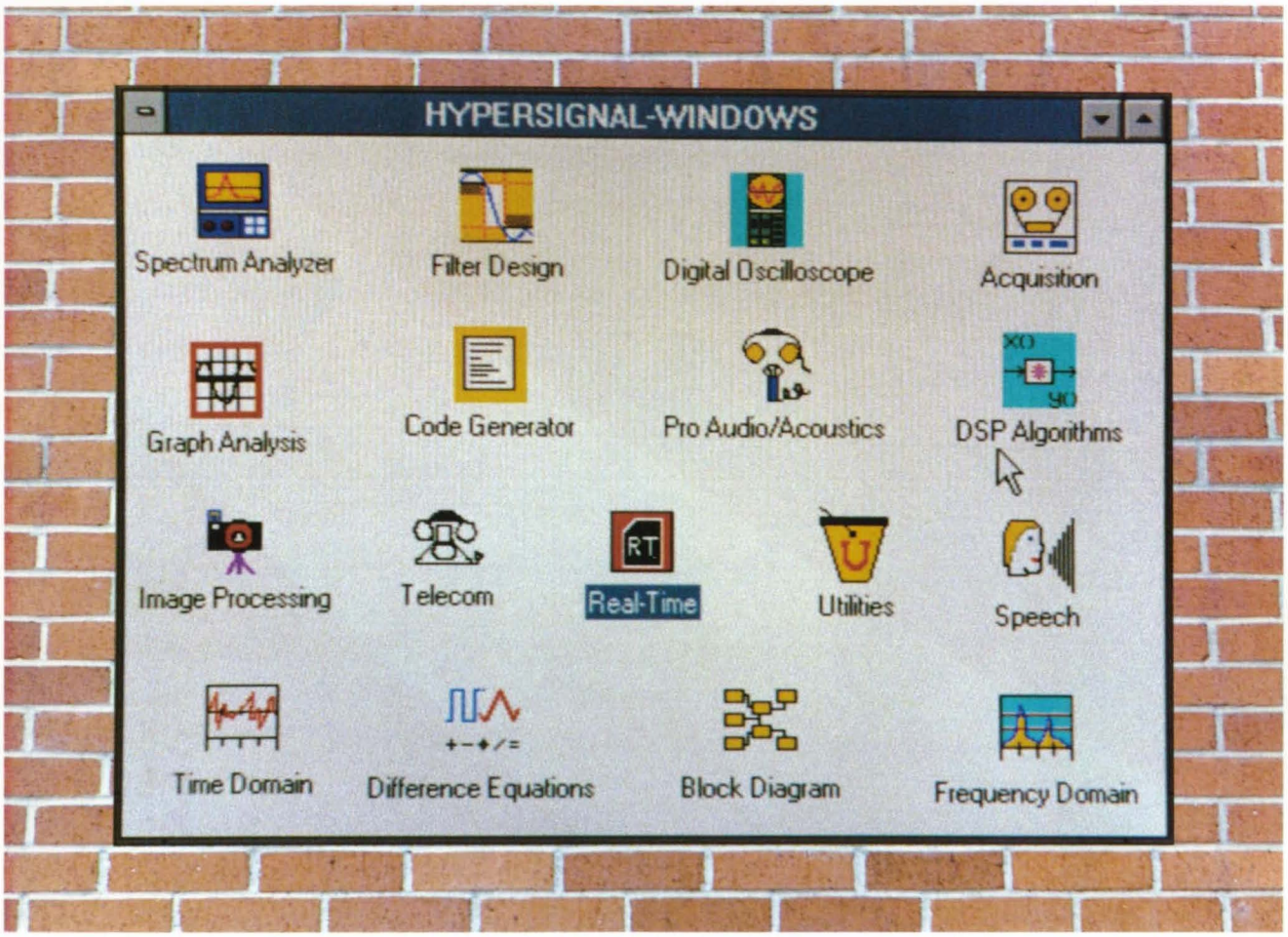

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